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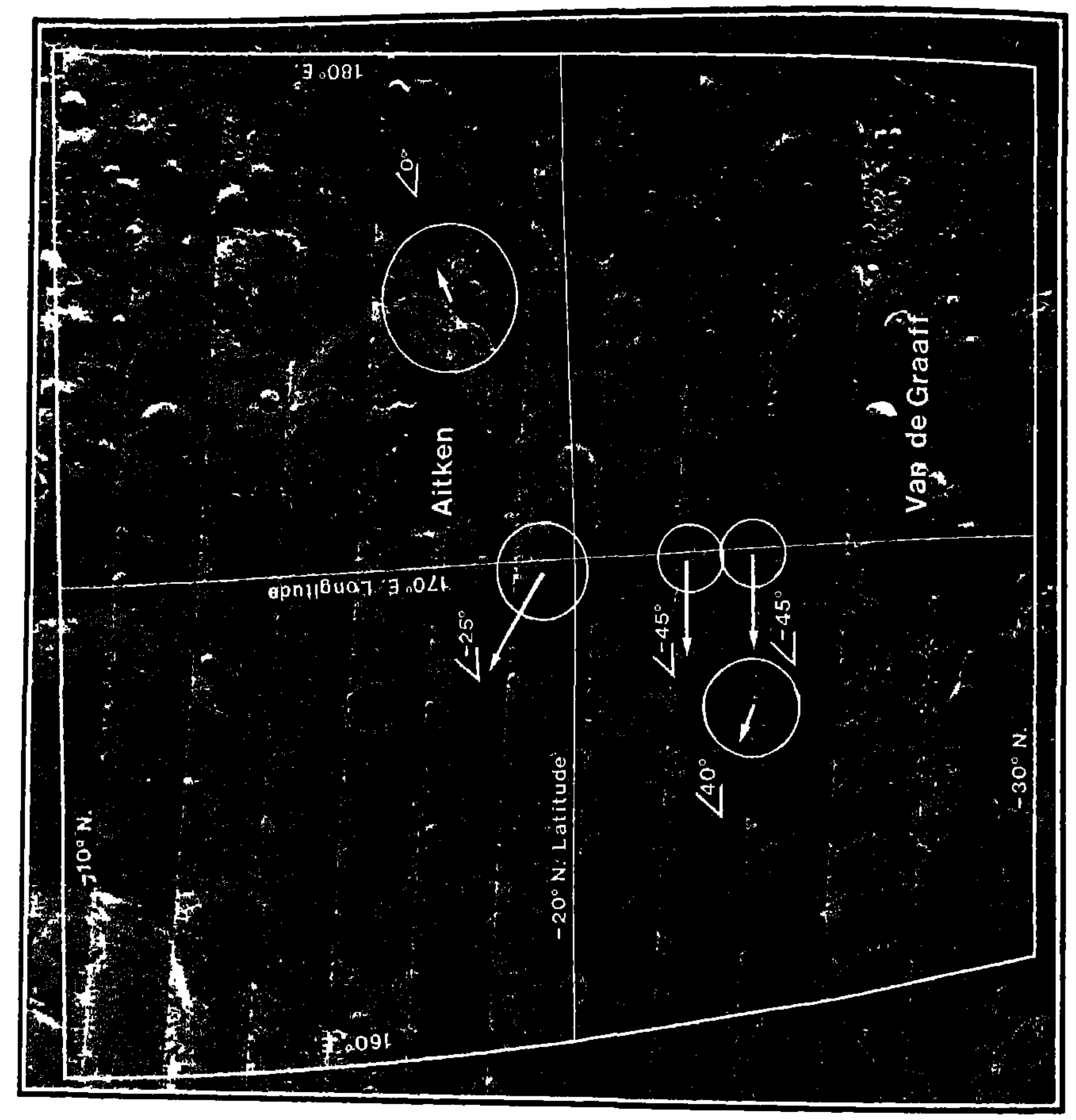

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Geochemistry

1455 Chemistry of the solid earth
A RECONNAISSANCE Sr AND Nd ISOTOPIC STUDY OF THE MESOZOIC CALC-ALKALINE GRANITIC BATHOLITHS OF THE SIERRA NEVADA AND PENINSULAR RANGES, CALIFORNIA
D.J. DePaolo (Dept. Earth & Space Sciences, UCLA, Los Angeles, CA 90024)

Plutonic igneous rocks of the Sierra Nevada batholith exhibit a range of Nd isotopic compositions [illegible] ... J. Geophys. Res., Red, Paper 1B0530

1460 Geochronology
ORIGIN/GEOLOGY OF THE DEEP PROFILE THROUGH ARCHEAN CRUST ... VREDEFORT ..., WITH IMPLICATIONS FOR EARLY CRUSTAL EVOLUTION
R.J. Hart (Bernard Price Institute Geophysics Research Unit, University of the Witwatersrand, Johannesburg 2001, South Africa)

The presence of Archean granite forming the core of an upturned and overturned sequence of strata at Vredefort, South Africa, has been known for over seventy years. [illegible] penetrate through a ~ 15 km thick section of the Archean crust, when moving from the contact of collar strata to the centre of the dome. The upper levels of the Vredefort crust are dominated by a relatively homogeneous Outer Granite Gneiss (OGG) displaying marked gradients in LIL elements. These rocks grade inwards into the deeper levels which occur in granulite facies metamorphism. The deeper levels of the Vredefort crust exposed in the central parts of the dome consist predominantly of felsic Inlandsee Leucogranofels (ILG) which occurs interleaved with inclusions of mafic meta-volcanic and metasedimentary rocks termed Steynskraal Metamorphic Zone (SMZ). [illegible] The results permit unique and direct tests on the theories of Archean crust forming processes. [illegible]
J. Geophys. Res., Red, Paper 1B1770

... large classical terrestrial triangulation networks. However, the combined adjustment of terrestrial and space data raises several theoretical problems, including the choice of appropriate reference systems, the a priori weighting of the various types of observations, the modelling of systematic errors and the conditioning of the network in terms of internal and external rank deficiencies. [illegible]
Bulletin Geodesique, Vol. 55, No. 1

1930 High-order harmonics of the gravity potential field and local gravity anomalies
HIGH DEGREE SPHERICAL HARMONIC EXPANSION OF GRAVITY DATA
Dezső Nagy (Gravity & Geodynamics Div., Earth Physics Branch, Dept. of Energy, Mines & Resources, Ottawa, Ontario, Canada K1A 0Y3)

A spherical harmonic expansion of the gravity field up to degree and order 300 was carried out. [illegible]
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1930 High-order harmonics of the gravity potential field and local gravity anomalies
MODELLING POSITION DEPENDENT ERRORS IN GRAVIMETRIC DEFLECTIONS OF THE VERTICAL
F.L. Clarke (Dept. of Civil Eng., Univ. of Newcastle, New South Wales 2308, Australia)

Comparisons of gravimetric and astrogeodetic deflections of the vertical in the Australian region [illegible]
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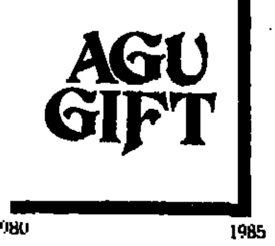
MODELS FOR CONTROLLING NATIONAL AND CONTINENTAL NETWORKS
V. Ashkenazi (Dept. of Civil Eng., Univ. of Nottingham, Nottingham NG7 2RD, England)

[illegible]

Editorial

An AGU Investment



It is now about 2 years since AGU acquired the building at 2000 Florida Avenue in Washington, D.C. That gave us, for the first time in 60 years, an independent and permanent headquarters location. The frequent moves were over, and the need to face annual rentals of nearly a quarter million dollars vanished. Besides that, it seemed that a substantial building offered a long-term protection against inflationary erosion of our assets. In fact, the annual appreciation of real estate in that part of the District of Columbia business district is about 10%. Moreover, the space in excess of the Union's own needs is fully rented. This provides a regular income which covers all the building's expenses. A piece of extra land can be used for future expansion in one of the most desirable locations of the city.

Presently the building still carries a substantial mortgage inherited from the prior owners, of \$1.285 million. Although by present conditions the interest rate is low (9¾%), the monthly payments of \$14,000 must be met. Fortunately this mortgage can be prepaid in 1986 without penalty. Depending on interest rates at the time, this may be in the best interest of the Union and generating the reserves to do so has become one of the major aims of the present fund-raising drive. To raise about \$100 per member (or only 20 tax-deductible dollars per year per member) seems to be a very modest goal. Many members can and should give much more. A debt-free building would give the Union a solid, appreciating capital asset, a small but steady rental income, and above all a central home for its activities.

H. E. Landsberg

EOS
TRANSACTIONS, AMERICAN GEOPHYSICAL UNION

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Cover. This group photo, taken 50 years ago at the AGU Twelfth Annual Meeting, identifies these participants: (1) Parkin; (2) McCombs; (3) ?; (4) Small; (5) Moon; (6) Allen; (7) Claire; (8) Horn; (9) McIlwraith; (10) Swick; (11) Alexanderson; (12) Stearn; (13) Duvall; (14) Robertson; (15) Adams; (16) Duerksen; (17) Heiland; (18) Ennis; (19) Belote; (20) Edmonds; (21) Harradon; (22) ?; (23) Ewing; (24) Capello; (25) Don Leet; (26) Fisk; (27) Peters; (28) Williamson; (29) Scott; (30) Vaughn; (31) Hazard; (32) Lomas; (33) Sewell; (34) Gish; (35) Littlehales; (36) Heck; (37) Clopsteg; (38) Whitten; (39) Bowie; (40) Sohon; (41) Humphreys; (42) Meade; (43) Fleming; (44) Wright; (45) ?; (46) Gregg; (47) Lambert; (48) Patterson; (49) Eggen; (50) Underwood; (51) Wait; (52) Gould; (53) McManus; (54) Woon; (55) Amros; (56) Sollenberger; (57) Marmer; (58) Dorsey; (59) McComb; (60) ?; (61) Heyl; (62) Marla; (63) Woolhiser; (64) ?; (65) Brown; (66) Schmidt; (67) ?; (68) Gordon; (69) Pagenhart; (70) Willis; (71) Culley; and (72) Mitchell. Still on the AGU rolls today are Ernest J. Parkin (1), Joseph L. Stearn (12), Jacob A. Duerksen (16), Roy O. Williamson (28) Oliver H. Gish (34), Charles A. Whitten (38), Buford K. Meade (42), Laurence M. Gould (52), and Frank L. Culley (71).

Piggyback Drilling in Kansas: An Example for the Continental Scientific Drilling Program

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M. E. Bickford

Department of Geology, The University of Kansas, Lawrence

As the development of plate tectonic theory has provided a framework within which to interpret new geological and geophysical data, the need for an organized deep-drilling effort on the continents has become apparent. Since the expense of such a venture will be large, it is important to perform as many scientific experiments as practical on each hole drilled. This paper is a report on scientific, administrative, and financial aspects of a drilling program in Kansas. Experiences related here should be of some use to other groups planning scientific drilling ventures.

Four holes were drilled to 0.5–1.1-km depth in Kansas as part of a hydrological study of the Arbuckle Formation. Two of the holes penetrated igneous rock of Precambrian age, and several meters of granitic core were recovered. At least one of the cores is highly magnetic and more radioactive than normal granite. Both cores have U/Pb zircon ages of 1340–1360 million years, presenting evidence for a previously unknown episode of intrusive activity. All four holes have been thermally logged with geothermal gradients ranging from 28° C/km to 36° C/km. The cased boreholes will be available in the future for additional experiments by other scientists.

Introduction

There is currently great interest in the continental crust, and much has been said about the desirability of 'piggybacking' purely scientific sampling and geophysical experiments onto drilling projects designed for other purposes. We have recently completed such a 'piggyback' drilling project in order to obtain samples of the buried Precambrian basement in Kansas and to obtain geophysical data for the crust in this region. The purpose of this paper is to relate to the interested scientific community how we went about this project and what some of our problems were. We will also present some of the scientific results in preliminary form and make recommendations to investigators, funding agencies, and organizations who may wish to promote this kind of scientific endeavor.

Continental Scientific Drilling Program

The Continental Scientific Drilling Program (CSDP) is a conceptual program that has not yet been formally or explicitly funded. The idea has evolved with the development of plate tectonic theory and the subsequent realization that while continental crust is complex, it may not be impossibly complex. Continental earth scientists have watched the tremendous success of the Deep Sea Drilling Project, which began in 1968, and they are confident that a similar well-planned scientific drilling program on the continent would lead to a better understanding of continental accretion and evolution. By 1974, interest had developed to the point that a workshop on continental drilling was held at Ghost Ranch, New Mexico. A drilling program funded at the level of less than \$15 million (1974 dollars) per year for about 10 years was suggested in the Ghost Ranch Report [*Shoemaker*, 1975].

Funding for the CSDP was never authorized by Congress, but by early 1978 the U.S. Geodynamics Committee realized that substantial mission-oriented drilling was being done by various state and federal agencies nationwide. A CSDP workshop, sponsored by the Geodynamics Committee, was held at Los Alamos Scientific Laboratory (LASL) in July 1978. The workshop was attended by approximately 100 scientists, representing more than 50 universities, government agencies, and corporations. A survey of the agencies represented at the workshop revealed that government continental drilling projects for fiscal 1979 were expected to cost approximately \$500 million and that cumulative drilling was expected to exceed 70 million feet. (This sounds like a lot of continental drilling, but it is only four inches for every man, woman, and child living in the U.S.). The survey also revealed a lack of interagency coordination and information on drilling projects.

When holes are drilled for scientific purposes, it is in the best interests of taxpayers to maximize the amount of scientific research done on each hole. In other words, multipurpose holes often have the potential to provide more scientific results per tax dollar spent. While we use the term (not without reservation) 'piggybacking' to designate additional experiments on deep drill holes, some might prefer 'add-on experiments' or simply 'holes-of-opportunity.'

One of the recommendations that resulted from the LASL meeting [*National Academy of Sciences*, 1979] was that the effectiveness of research drilling should be maximized by cooperative effort among scientists (often with different objectives) and by providing a mechanism for communication among agencies, institutions, industry, and interested scientists. This paper is a report on a cooperative multipurpose drilling project in Kansas that involved several scientists, funding agencies, and objectives.

Arbuckle Project: Opportunity for Deep Drilling

The Arbuckle Group of Cambro-Ordovician age consists essentially of dolomite and contains significant oil and gas reserves in central and south central Kansas. The unit is also used as a reservoir to dispose of moderate amounts of industrial liquid waste and saline water, which is produced in conjunction with hydrocarbon production throughout the state. The Arbuckle is also an important freshwater aquifer in extreme southeastern Kansas and adjacent states.

Little is known about the regional geohydrology of the Arbuckle Group, either as an individual unit or as it relates to other rock units. Also unknown are the ultimate effects of continued large-scale injection on the hydraulic and physicochemical characteristics of the aquifer and the potential for contamination of overlying freshwater aquifers and those parts of the Arbuckle that contain freshwater.

In 1976 a cooperative program between the U.S. Geological Survey and the Kansas Geološical Survey was begun. The purpose of the study was to determine the regional geohydrologic characteristics of the Arbuckle Group to include definition of flow patterns in the Arbuckle and in relation to other overlying units, determination of hydraulic parameters in the various units, and determination of regional chemical quality. Test data procured from oil exploration companies are being analyzed to accomplish this objective.

Additional funding to the Kansas Geological Survey became available in FY 1979 and FY 1980 for the purpose of the test drilling and installation of deep monitor wells. This funding was matched and increased by the U.S. Geological Survey, the U.S. Army Corps of Engineers, and the Kansas Department of Health and Environment; the project was expanded to include determination of hydrologic properties of the Arbuckle and other units by drilling at specific locations. We were not involved professionally in any aspect of the Arbuckle project when it was originally funded.

However, we realized that valuable petrologic and geophysical data could be obtained if these holes could be deepened by about 100 m to penetrate the crystalline basement. Four drilling sites were selected. Three of the four sites were selected so that, in addition to the hydrologic study, basement rock samples and geophysical data could be obtained from the same holes. Two of the sites were located above intense, circular magnetic anomalies, the third was located in a region where sparse well control indicated a terrane of silicic volcanic rocks in the basement.

We received funding from LASL *and* the U.S. Department of Energy (DOE) to deepen the first two holes, recover core from the basement, and perform high-quality heat flow measurements in the holes. Funding was also received from a separate LASL contract to deepen the third hole; however, severe circulation problems developed within the Arbuckle Formation before the 'piggyback' experiment could begin. All of the money from that contract was returned to LASL.

Cost of Drilling Operations

A contract was awarded in September 1979 in the amount of \$444,701 for work to be performed at the first three sites. A second contract, in the amount of \$129,341 for work to be performed at the fourth site, was awarded in April 1980. Seventeen drill-stem tests were completed for the purpose of determining the hydraulic relationships between the Arbuckle and other major overlying aquifers. Three cores of the Arbuckle were collected in addition to the basement cores, and these are currently being analyzed under a third contract. A complete suite of geophysical logs, including vertical flow determinations, were completed at each site. Also, acoustical televiewer photographs were taken over selected intervals at three sites. Water samples have been collected at three sites and are undergoing complete chemical analyses, including determinations for age dating with lithium, bromine, strontium, deuterium, carbon 14, and tritium.

The increased incremental cost of approximately \$9000 per hole for coring in the Precambrian section of two holes is included in the above figures. Most of the preliminary scientific results reported here are a direct result of this small additional expenditure, thus demonstrating the value of 'piggybacking.'

Geologic and Tectonic Framework

The Midcontinent portion of North America is the most stable part of the continent, tectonically. The region is relatively aseismic, and there has been no significant deformation of the crust since at least the Late Paleozoic. The major tectonic elements of this region are (1) the southern extension of the Central North American Rift System (Midcontinent Rift; Midcontinent Geophysical Anomaly; Figure 1); (2) the Nemaha Ridge; and (3) the Central Kansas Uplift.

The Central North American Rift System [*Ocola and Meyer*, 1973; *Chase and Gilmer*, 1973] can be traced from central Kansas across southeastern Nebraska, Iowa, and Minnesota to its outcrop area in the Great Lakes region. The rift is marked by pronounced gravity and magnetic anomalies [*King and Zietz*, 1971; *Lyons*, 1950; *Thiel*, 1956] and is underlain by mafic igneous rocks, mostly basalt and gabbro, and arkosic sedimentary rocks. The feature is generally regarded as an abortive continental rift which occurred about 1100 m.y. ago [*Goldich et al.*, 1961; *Silver*

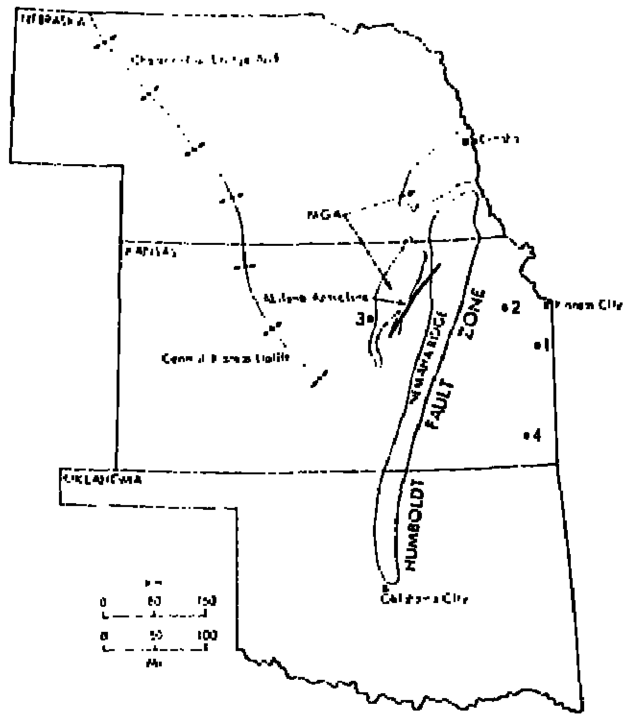

Fig. 1. Regional structural uplifts in the Kansas vicinity. Drill sites are numbered in chronological order of drilling. The Midcontinent Geophysical Anomaly is denoted by MGA.

and Green, 1963, 1972; *Goldich et al.*, 1966; *Chaudhuri and Faure*, 1967; *Van Schmus*, 1971].

The Nemaha Ridge is a striking tectonic feature which was intermittently active during Paleozoic time. It is certainly a major crustal fracture zone, for mylonitized basement rocks have been brought up from within it, and cataclasis is a common feature along its extent from northeastern Kansas into Oklahoma [*Bickford et al.*, 1981]. The fault zone is upthrown on the western side, forming the feature known as the Nemaha Ridge. The eastern flank of the Nemaha Ridge is bounded by the Humboldt Fault Zone, which has minor microearthquake activity [*Steeples et al.*, 1979]. Earthquakes as large as Modified Mercalli Intensity VII have occurred along the Humboldt Fault Zone in historic time [*DuBois and Wilson*, 1978].

The Central Kansas Uplift (Figure 1) is a broad region in which basement rocks have been moved upward and which is characterized by fault zones and cataclasis. The feature is evidently coextensive with the Cambridge Arch in Nebraska. Although the Central Kansas Uplift was active during the Paleozoic, little is known about its Precambrian history. A relatively high level of microearthquake activity (more than 20 events per year larger than magnitude 1) occurs along this structural trend [*Steeples*, 1980].

The crystalline crust in the Midcontinent is buried under about 1000 m of sedimentary rocks and is thus mostly known from studies of numerous drill holes [*Muehlberger et al.*, 1966; *Goldich et al.*, 1966; *Lidiak et al.*, 1966; *Lidiak*, 1972, *Bickford et al.*, 1979; *Bickford et al.*, 1981; *Kisvarsanyi*, 1980]. The crust in this area is notable for its predominantly granitic composition. Mafic rocks are rare, and metamorphic rocks, though present in many places, are not abundant. A major feature of the crystalline crust in the Midcontinent is its division into a *northern terrane*, consisting of somewhat deformed and sheared granitic rocks and lesser amounts of metamorphic rocks that occur in northern Missouri, northern Kansas, and Nebraska, and a *southern terrane* totally dominated by silicic volcanic rocks and associated epizonal granitic plutons. The southern terrane can be traced from northern Ohio across Indiana, Illinois, southern Missouri, southern Kansas, and Oklahoma into the Texas Panhandle. Geochronological studies [*Bickford et al.*, 1981; *Denison et al.*, 1981] indicate that the northern terrane is generally older, with many rocks yielding ages of 1640 m.y. (U-Pb, zircon) to 1740 m.y. (Rb-Sr), whereas the southern terrane varies in age from about 1475 m.y. in the St. Francois Mountains of southeastern Missouri [*Bickford and Mose*, 1975] to about 1380 m.y. in southwestern Missouri, southeastern Kansas, and Oklahoma [*Bickford and Lewis*, 1979; *Bickford et al.*, 1981].

Lying upon the crystalline crust in the Midcontinent region is a section of sedimentary rocks ranging from about 150 m in thickness over parts of the buried Nemaha Ridge to as great as 2 to 3 km thick in basins such as the Hugoton Basin of southwestern Kansas and northwestern Oklahoma. The average thickness of the sedimentary rock section in eastern Kansas where our drilling projects were done is about 1 km. The rocks range in age from late Cambrian to Pennsylvanian or Permian in eastern Kansas, but there is a thick Cretaceous section in central Kansas, and rocks of Tertiary age occur on the western plains. Paleozoic rocks in the Midcontinent region are mostly marine in origin and are dominated by carbonate units and shale.

Scientific Results

The authors had significant input as to the location of the holes, and their sites were chosen to maximize potential information from the basement, subject only to the general suitability of the location to the primary mission of the drilling project, i.e., the hydrologic study of the Arbuckle. The legal descriptions and locations of holes drilled are given in Table 1.

Drilling at the first hole (Miami County) was completed on December 10, 1979. Approximately 8 m of 8.7-cm-diameter core of fresh granite were recovered from a depth of 858 to 866 m. This hole was located on a sharp 1000-γ circular aeromagnetic high, shown as locality 1 on Figures 1 and 2.

The second hole (Douglas County; locality 2 on Figures 1 and 2) was also located on a circular magnetic high with an amplitude of about 1100 γ; drilling was completed on March 19, 1980. Three meters of 10-cm-diameter core of fresh granite were recovered from a depth of 905 to 908 m. The 3 meters represents only 58% recovery of the 5.2 meters cored. We were very fortunate not to lose all of the core, as it started slipping out of the core barrel during the trip up the hole. The core catcher barely hooked the core again and prevented disaster. We were not charged for the core that was lost.

Two additional holes (localities 3 and 4 on Figures 1 and 2) were drilled to depths of 1117 m and 554 m, respectively. Severe lost-circulation problems developed on both of these holes within parts of the Arbuckle Formation, and drilling was halted at that depth because the primary objective of the drilling had been met. Penetration of Precambrian basement at sites 3 and 4 would have cost an additional (possibly very large) undetermined amount of money.

The scientific data we expect to obtain from the drill core and from the geophysical measurements include the following: age, petrography, major and trace element chemical composition, density, and remanent magnetism of the rocks encountered; heat flow; and heat production of the rock material. The holes into basement can be made suitable for hydrofracturing experiments to measure in situ stress, provided future funding becomes available. The holes will be available to other scientists for other experiments within 2 years. Interested individuals should contact the authors of this report.

TABLE 1. Legal Description of Drill-Hole Locations in Kansas

	Location	Total Depth
Douglas County	SE ¼ NW ¼ NW ¼ Sec.13, T12S, R17E	908 m
Labette County	Center of SE ¼ Sec.22, T31S, R20E	553 m
Miami County	SE ¼ SW ¼ SE ¼ Sec.18, T18S, R23E	866 m
Saline County	SW ¼ SW ¼ SW ¼ Sec.32, T13S, R2W	1117 m

Geothermal Gradients

Preliminary thermal logging has been performed on all four holes by personnel from David Blackwell's laboratory at Southern Methodist University. The thermal logging equipment was not capable of reaching the bottom of the holes, so these data should be considered preliminary, pending results from deeper logging. Samples of core or well-cuttings have been sent to Blackwell's laboratory for thermal conductivity measurements. The following geothermal gradients have been measured to date in the four holes drilled on this project:

Location	Gradient	Depth Logged
Douglas County	30.3°C/km	565 m
Labette County	28.5°C/km	520 m
Miami County	36.0°C/km	395 m
Saline County	30.7°C/km	585 m

A final report on thermal logs and heat flow at these sites is available from the authors or from Blackwell.

Preliminary data from Blackwell indicate an unusually high rate of radioactive heat generation, about 11 heat generation units, in the core from the Miami County hole, compared with the 5 to 6 heat generation units for typical granites.

Petrographic and Isotopic Studies

The rock samples recovered from coring of Precambrian basement at sites 1 and 2 were studied by Bickford and Wendel J. Hoppe of the Isotope Geochemistry Laboratory of the University of Kansas. The results are briefly summarized below:

Petrography. The composition and texture of the rock from Site 1 (Miami County, Kansas; sample MI-4) was determined from study of 20 thin sections taken at even intervals along the 8 m of the core. The rock is coarse-grained granite and is composed essentially of microcline-perthite, plagioclase, quartz, biotite, and minor muscovite. Sphene, commonly somewhat altered to leucoxene, and magnetite are abundant accessories, and zircon, apatite, pyrite, and fluorite are also present. The rock is not foliated, and the presence of large megacrysts of microcline-perthite is notable.

We made six thin sections from the 3 m of core recovered at site 2 (Douglas County, Kansas; sample DG-3). This rock is also granite, and it is mineralogically almost identical to the sample from Miami County. The principal difference between the two samples is that DG-3 is medium grained and lacks the large microcline-perthite megacrysts which characterize the Miami County core.

Isotopic Studies. We measured the U/Pb ages of zircons from both cores by standard methods of isotope dilution and mass spectrometry. Both cores yielded an abundant zircon separate, so we were able to obtain a number of zircon fractions of varying U/Pb ratio for analysis. The results of these age determinations are shown in Figures 3 and 4, in which the data are plotted on 'Concordia' diagrams [*Wetherill*, 1956].

We analyzed six zircon fractions of the Miami County core, obtaining an age of 1361 ± 6 m.y. (1 σ), and six zircon fractions from the Douglas County core, obtaining an age of 1339 ± 12 m.y. (1 σ). These ages are significantly lower than any previously determined from the Precambrian of Kansas or Missouri. Our previous studies have yielded ages of about 1630 m.y. for cataclastically deformed granitic rocks and a single sample of rhyolite from northern Missouri and Kansas, about 1460–1475 m.y. for rocks in the St. Francois Mountains of southeastern Missouri and isolated plutons in northern Kansas and Missouri, and 1380–1400 m.y. for rhyolites and epizonal granites in southwestern Missouri, southeastern Kansas, and Oklahoma.

Forum

Re: 'Hydrology'

R. L. Nace in 'Hydrology Comes of Age' (*Eos, 61* (53), 1980), did not mention one rather important contribution to IHD made by the U.S. Work Group on Education and Training.

In 1965 the U.S. National Committee for the IHD established a Work Group on Education and Training, which was emphasized by the U.S. delegation at the 1967 IUGG conference. A detailed outline of a 'Hydrology and Water Resources Syllabus' was developed by L. L. Kelly of the U.S. Agricultural Research Service and presented to the U.S. committee in draft form.

The work group continued to work on the syllabus until 1970, refining and cross referencing entries until a rather complete document was produced. The late Leo A. Heindl, executive secretary for the IHD committee, took a special interest in the 'Syllabus' as a method of focusing attention on the world's need for bringing hydrology into global perspective.

Approximately 3000 copies of 'Hydrology and Water Resources, a Syllabus of References for the Water Environment' were printed by the National Academy of Sciences in 1972 and distributed worldwide through UNESCO.

It is my understanding that several of the important IHD training programs conducted in several countries used the subject syllabus as a reference, especially for identifying free literature available from the United States Government Printing Office.

Joseph M. Kennedy
GRI Operator Corporation

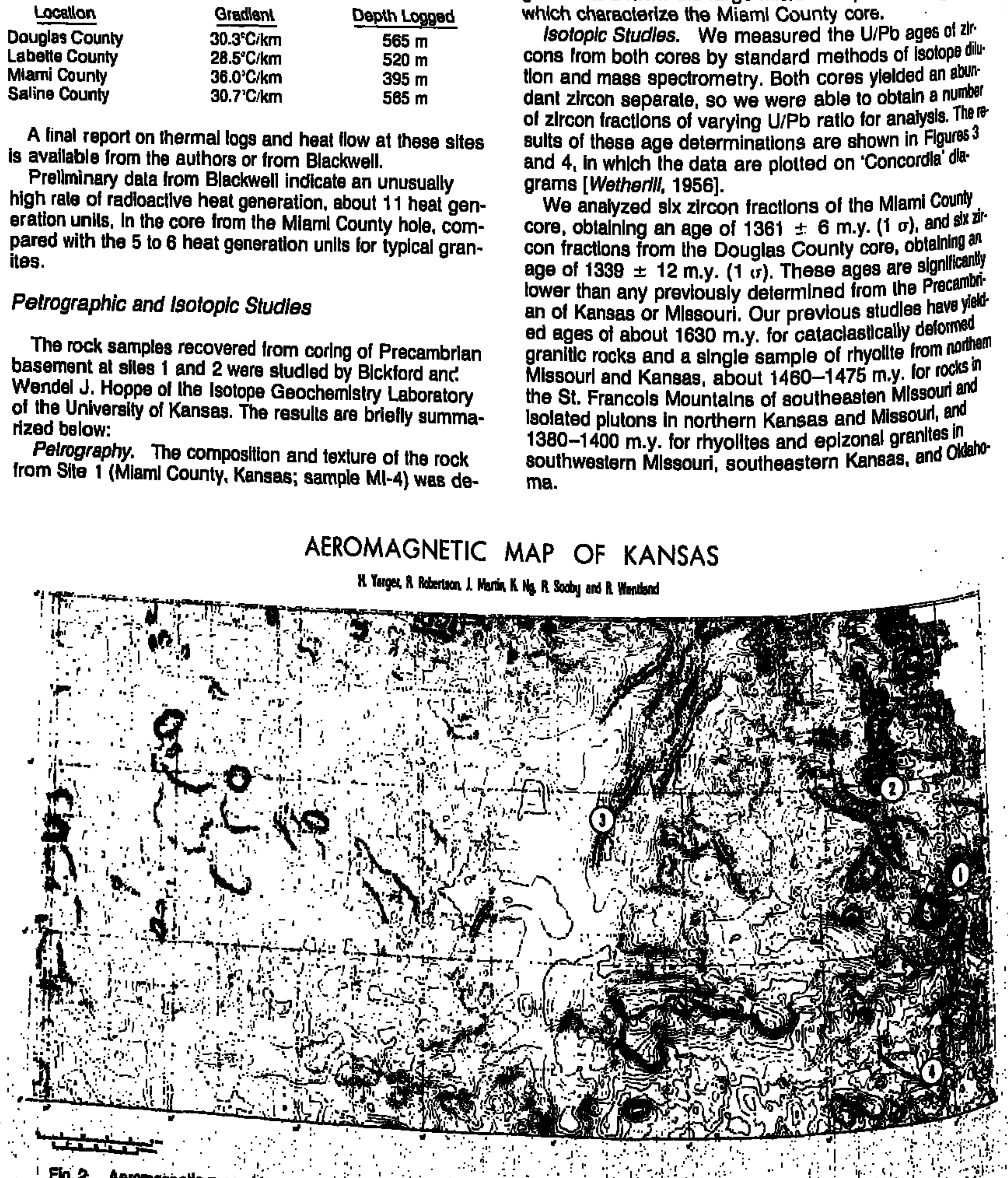

Fig. 2. Aeromagnetic map of Kansas with 50-γ contour interval. Drilling sites are shown by the numbers 1 through 4. Drill sites 1 and 2 are located on the maximum aeromagnetic anomaly observed after reduction to the magnetic pole.

The fact that both cores were obtained from drilling on pronounced magnetic anomalies, that both are mineralogically similar and contain rather abundant magnetite and sphene, and that both yield U/Pb ages from zircons that are in the range of 1340–1360 m.y. and are younger than other Precambrian rocks in this region suggests that these rocks are representatives of a suite of Late–Middle Proterozoic intrusives that have distinctive mineralogy and geophysical properties. This contention is borne out by some of our studies of other basement samples. These are summarized below:

1. *Core from Jackson County, Missouri.* Rock is granite that contains abundant magnetite and sphene; texture and essential mineralogy similar to Miami County and Douglas County, Kansas, cores; U/Pb age of zircon suite: 1365 ± 10 m.y.; drilled on large, circular magnetic anomaly.

2. *Drill cuttings from Riley County, Kansas.* Rock is granite but does not appear to have the abundant sphene and magnetite that other samples do; drilled on weak but distinctive circular magnetic anomaly; U/Pb age of zircons: 1378 ± 4 m.y.

We have not yet determined whether this suite of rather distinctive plutons has a distinguishing major element or trace element chemistry, but that will be one of our immediate goals.

Administrative Problems

Problems in Obtaining Piggyback Funding

The problems we encountered in obtaining the relatively small ($30,000) additional amount of funding needed to recover core of Precambrian rocks in two holes and perform high-quality heat flow measurements in four holes underscore the need for an official CSDP effort complete with funding. The original drilling money ($225,000) for the Kansas Geological Survey for the Arbuckle Project was appropriated by the 1978 Kansas Legislature. This was matched by USGS Water Resources Division, Kansas District, dollar for dollar, then increased by a few thousand dollars to provide the total funding needed. The Kansas Department of Health and Environment and the Kansas City District of the U.S. Army Corps of Engineers contributed additional funds, bringing the total to about $570,000.

When the hydrologic drilling program was first proposed in 1976, we realized the possibility of drilling into the basement to obtain additional scientific information at a relatively small additional cost. It was not until the 1978 legislative authorization occurred that formal attempts were made to secure funding for additional experiments. While in retrospect we could have started our efforts to find additional funding earlier, the funding for the drilling phase of the Arbuckle Project was in doubt until the final days of the Kansas legislative session (April 1978).

Once initial funding of the Arbuckle Project had been authorized, efforts to raise money to drill 60–100 m deeper to reach the Precambrian rocks and obtain bottom-hole core were begun. Several agencies were contacted by telephone prior to sending formal proposals to the National Science Foundation (NSF) and to the National Uranium Resource Evaluation (NURE) program of the Department of Energy. The drilling did not fit the NURE mission closely enough, so the proposal was turned down by NURE reviewers.

The proposal submitted to NSF involved considerable additional cost for hydrofracturing in the Precambrian to measure in situ stress in two holes, for recovery of oriented core from the Precambrian, and for heat flow measurements. The total amount of the proposal was approximately $145,000, admittedly a large sum for NSF. The proposal was interdisciplinary in nature, encompassing aspects of geology, geochemistry, geochronology, petrology, and geophysics. NSF did not fund our proposal. The consensus of the reviewers' comments was that the scientific goals of our proposal were sound and that 'piggybacking' was a desirable way to minimize the costs of obtaining basement rock samples. However, most of the reviewers questioned whether the scientific return expected was worth the cost.

At this point we were discouraged, and we suspected that the opportunity to obtain basement rock material and geophysical data would be lost. Several months later, however, a colleague at another university suggested that the Geothermal Division of DOE and the geothermal program of LASL might fund part of our proposal. LASL subsequently provided about $9000 for drilling, and DOE provided about $20,000 for drilling and heat flow measurements. All other proposed experiments were deleted from the project.

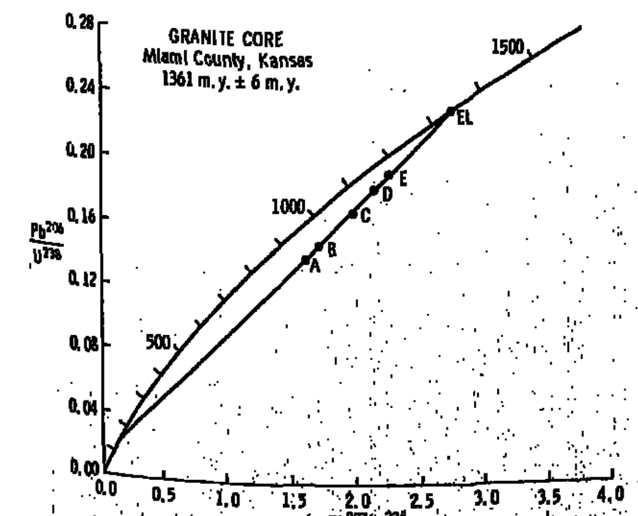

Fig. 3. Concordia plot for zircons from granite recovered at site 1.

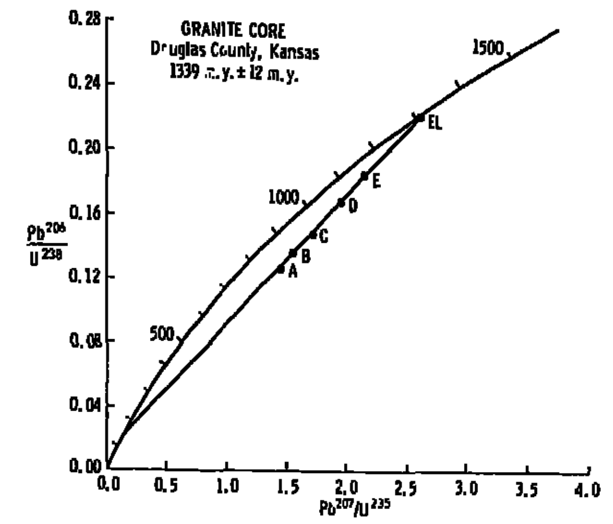

Fig. 4. Concordia plot for zircons from granite recovered at site 2.

Necessity for Timely Administrative Action

Strong arguments can be made for the necessity of generating invitations for bids (IFB's) and awarding contracts for expensive undertakings such as reported here. The authors have no qualms about such requirements when scheduling is not a problem and the work can be accomplished in a routine manner. However, there are many occasions when money and time could be saved if the system were more flexible, i.e., consideration should be given to allowing for unique circumstances that frequently arise. Two examples encountered in this program may help to clarify the problem.

The first drilling site was originally drilled as a private minerals exploration test. When the company was preparing to plug the hole, the opportunity was presented to the U.S. and Kansas geological surveys to take over the hole. The authors and U.S.G.S. personnel determined that work consisting of running drill-stem tests, logging, coring of basement rock, installation of casing, and conversion of the hole into a monitor well could have been done with the rig already on the site for approximately $40,000 to $50,000. However, the time required to issue a sole-source contract precluded the possibility of retaining the rig. Consequently it was necessary to generate an IFB and award a contract, a process that took several months.

Potential bidders had trepidation about reentering an existing hole, and this concern was mirrored in the bids that were received. Quotes on the reentry alone were equivalent to costs that could be expected in drilling a new hole. The costs for the portion of the contract that was awarded for site 1 were about $100,000, at least twice as much as our estimate of costs had we used the rig that was in place at the site.

The second example occurred with regard to site 2. As work was proceeding, a private concern offered to contribute about $30,000 for 150 m of additional basement drilling and testing. Since this additional work was not outlined in the original contract, we attempted to negotiate a sole-source contract to allow the contractor to drill deeper. We found that the time necessary for price quotes and other paperwork was excessive, especially considering that rig expenses while waiting for a contract were in excess of $100/hour. On the other hand, if additional basement drilling was put off until the original contract was completed and the rig released, it would have been necessary to write a new IFB and award a new contract. At that point the available funds would not have been sufficient because of remobilization costs for the drilling rig. Again, largely because of lengthy administrative requirements, the work could not be accomplished.

Recommendations

To Potential Investigators

1. It is obviously advantageous to plan as far ahead as possible and to contact many prospective funding agencies, as well as fellow scientists.

2. While there may not be a practical upper limit on the number of scientists involved in experiments on a project, it is clear that one particular individual must have the authority for immediate on-site action or reaction to problems that arise, including the cancellation of entire experiments if adverse or unusual conditions warrant such action.

3. We found the services of an experienced drilling consultant to be invaluable during the planning stages of our project, since neither of the authors had drilling experience on holes deeper than 300 m prior to this project.

4. Obtain cost estimates from private industry and then double them for budgetary planning. The combination of lag-time between planning and drilling, inflation, and government lawyers' insistence upon a contract that rigidly specified drilling performance resulted in costs to us approximately double those available to private industry.

To Funding Agencies

1. Cooperative effort between and among funding agencies enabled us to provide results to several agencies without any particular agency being financially devastated.

2. Contracts should be flexible enough to allow for failure of one or more experiments. Our unsuccessful effort to obtain core on a third hole for LASL was assuaged by returning all of the money to LASL. It is not clear what would have transpired had we spent all the LASL money trying to regain circulation without obtaining the desired core.

3. Proposals for drilling or 'piggybacking' projects should be reviewed by a special interdisciplinary panel that should include some scientists who are familiar with deep drilling and its risks of failure. Although NSF did not fund our proposal, we were pleased that they convened a special plenary session of their review panels to consider our proposal.

To Legislative Bodies

1. We are among those in the scientific community who believe that a well-funded CSDP would be a good investment in future energy and mineral resource evaluation. The scientific results would assist in development of a realistic framework upon which to base future exploration by industry.

2. A scientific piggyback drilling fund should be available somewhere in the federal government (preferably NSF). Administratively, NSF could fund projects involving drilling and related interdisciplinary studies, but the money involved would have to be diverted from other research normally supported by the programs of the Earth Science Division.

3. Flexibility needs to be built into the contracting process in several areas:

a. The capability to take over 'holes-of-opportunity' from industry with a couple of days' notice must be incorporated into the CDSP in order to take advantage of the many thousands of feet of 'free' hole occasionally made available by industry. Controls on this process must be maintained by a highly qualified scientific board rather than by a staff of accountants and lawyers. As a direct result of our experience in this project, the Kansas Geological Survey has received special authorization from the state of Kansas to take over wells from industry and drill deeper or perform experiments. Authorizations are made on a case-by-case basis by telephone, with the constraint that we must have sufficient funds in the budget to cover the expected costs of the additional drilling or experiments. The key to a successful piggyback drilling program in a long-term sense is the capability to act or react spontaneously and almost instantaneously to opportunities.

b. The capability to modify existing contracts rapidly to take advantage of 'bottom-hole money' offered by private industry must be incorporated into the contracting procedure.

c. The differences in drilling rates charged to government agencies, compared to those charged to private industry, are unacceptably high. A thorough study of comparative contractual practices is needed to determine the exact reason for this rate differential.

Acknowledgments

Cooperation among and funding from the following agencies is appreciated: Kansas Department of Health and Environment, Kansas Geological Survey, Los Alamos Scientific laboratory, U.S. Army Corps of Engineers, U.S. Department of Energy, and the U.S. Geological Survey. Tony Gogel and Jay Gillespie of the Kansas District of the Water Resources Division of the U.S. Geological Survey were especially helpful in the planning and operational aspects of the piggyback drilling. The contracting and drilling processes for the Arbuckle project were carried out under their supervision.

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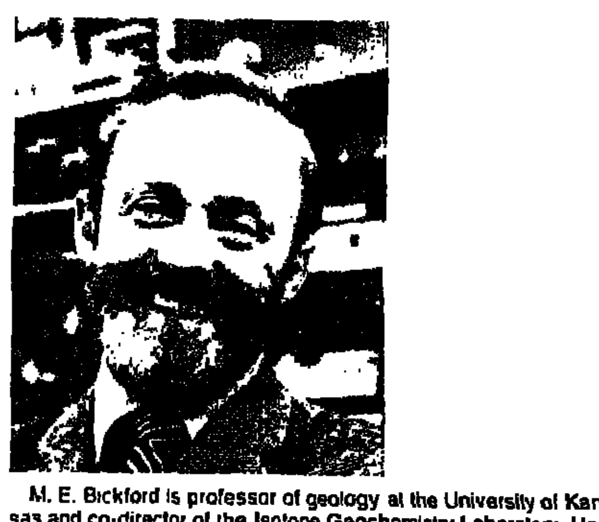
Don Steeples is presently chief of the environmental geology and geophysics section of the Kansas Geological Survey and chairman of the geophysics program at the University of Kansas. He received B.S. (1969) and M.S. (1970) degrees in geology from Kansas State University and M.S. (1974) and Ph.D. (1975) degrees in geophysics from Stanford University. While at Stanford he worked part time for 3 years as a geophysicist for the USGS National Center for Earthquake Research. His research interests include seismicity and tectonics of the Midcontinent, shallow exploration seismology, and geophysical exploration for kimberlites. He spends weekends and vacations as a wheat farmer in northwestern Kansas



M. E. Bickford is professor of geology at the University of Kansas and co-director of the Isotope Geochemistry Laboratory. He received the B.A. degree from Carleton College, Northfield, Minnesota, in 1954. Following military service, he obtained the M.S. (1958) and Ph.D. (1960) degrees at the University of Illinois. His research is primarily aimed at understanding the processes by which continental crust is formed and its evolution through time. This research interest has recently involved him in studies of the relatively young rocks of the Idaho Batholith, but mostly he has worked on the geochronology and isotopic geochemistry of Proterozoic rocks in Colorado, Missouri, and the buried crust of the Midcontinent region.

News

P78-1 Satellite Status

The P78-1 satellite was launched on February 24, 1979, into a 580-km sun-synchronous polar orbit. This U.S. Air Force Space Test Program mission is currently operational and continues to collect important earth and solar-related data.

Gamma ray spectrometers supplied by Lockheed (Palo Alto) measure sources with excellent spatial ($\approx$ 100 km), spectral (3.5 keV FWHM at 511 keV), and temporal resolution (32 ms). Characteristics of energetic particle fluxes in the vicinity of the satellite are also monitored by Lockheed. Cosmic-γ ray bursts have been observed with fine energy resolution. Mappings have been made of several bremsstrahlung X ray events resulting from electron precipitation, events which varied strongly with time (flux changes by 1–2 orders of magnitude in 5–10 s) and which extended coherently over distances of several hundred kilometers. Energy spectra of precipitating electrons have been observed with peaks as narrow as 20 keV, suggesting wave-particle interactions with waves of very narrow bandwidth ($<$ 1 kHz).

Collimated (20 and 60 arc sec FWHM) and uncollimated X ray spectrometers of The Aerospace Corporation and the Naval Research Laboratory (NRL) record solar active region and flare data with high spectral ($\lambda/\Delta\lambda \sim 10^3$), temporal (32 ms), and spatial resolution. About 200 solar X ray lines have been observed. Coronal flare electron densities ($\leq 2 \times 10^{12}$ cm^{-3}) and temperatures (2–20 $\times 10^6$K), differential emission measure, the number of electrons ($\leq 2 \times 10^{38}$), and the plasma volume ($\leq 2 \times 10^{26}$ cm^3) have been determined with high time resolution ($\sim$ 1 min). The spatial extent of solar active regions and flares has been determined from monochromatic X ray maps ($\geq$ 20 arc sec). An NRL white light coronagraph monitors the plasma outflow in the sun's outer corona and into the solar wind. Frequent transient mass releases of up to 10^{13} kg of solar plasma at radial velocities of up to 10^3 km s^{-1} have been observed, widely distributed in heliographic latitude.

An aerosol monitoring experiment provided by the University of Wyoming measures the vertical extinction caused by aerosols and the concentration of ozone in the earth's stratosphere. A springtime blanket of aerosols in the boundary layer over the north polar cap of the earth has been discovered.

An NRL/Los Alamos X ray payload is used to monitor the frequency and location of cosmic X ray bursts. The intensity of known cosmic X ray sources as well as of auroral X rays is also recorded. Electrons in high-latitude auroral zones during magnetic storms and even quiet times are also detected by an Air Force Geophysics Laboratory payload. Discrete arcs and diffuse forms have been observed. Finally, a U.C. Berkeley EUV spectrometer is used to measure the intensity, spatial distribution, and time variations of radiation in the upper atmosphere. High-resolution spectroscopic studies of EUV nightglow, EUV airglow from the South Atlantic Anomaly, and tropical UV arcs have been made for the first time.

This news item was written and submitted by Peter Landecker of the Space Sciences Laboratory at The Aerospace Corporation.

Volcano Activity Increases

The Cascade volcanoes in the Pacific Northwest may be entering a period of heightened activity, reports the U.S. Geological Survey. Seismic rumblings also have increased along the northern part of the San Andreas fault, indicating additional tectonic activity. In response to these stirrings, the USGS plans to expand its volcano monitoring, hazards mapping, and risk management.

This expansion includes four new starts scheduled for this fiscal year, according to Roy A. Bailey, coordinator of the Volcano Hazards Program at the USGS National Center in Reston, Virginia. Monitoring equipment will be installed on Mount Ranier (Washington), Three Sisters (Oregon), Lassen Peak (California), and Mono-Inyo (California). Seismographs, tiltmeters, and geodimeters will be installed to monitor changes in these volcanos that could signal an impending eruption. Most of these monitoring systems will be installed in July or August, Bailey said, and will remain in place for several years until a data base has been established.

Volcanic emissions of carbon dioxide, sulfur dioxide, and hydrogen will also be scrutinized. Monitoring for radon and helium has not been included in this year's plans for monitoring systems, Bailey said.

Stirrings in the Cascades include the intense steaming of Mount Baker in 1975 and the continuing melting of glacial ice within Mount Baker's Sherman Crater; bursts of quakes near Mount Shasta and at Mount Hood; and last year's eruptions of Mount St. Helens.

USGS scientists also have observed increased earthquake activity in California during the last year and a half. This reverses the trend of relative quiet of more than a decade. 'These changes are part of a larger picture of instability of the earth's crust,' said Robert E. Wallace, chief scientist for the USGS Office of Earthquake Studies in Menlo Park, California.

Californians recently marked the 75th anniversary of the magnitude 8.3 San Francisco earthquake of April 18, 1906. Will the increased seismic activity lead to another similar quake? Probably not in this century, says a team of USGS scientists.

Seismicity in the San Francisco area appears to be controlled by a cycle of stress release and recovery, according to Darrel G. Herd of the USGS. He and William L. Ellsworth, Allan G. Lindh, and William H. Prescott recently completed an historical study of San Francisco quakes.

Herd suggests that the recent return of magnitude 5 quakes may forecast the reappearance of magnitude 6 or 7 quakes in the Bay area as stress accumulates, eventually leading to the next magnitude 8 shaker. The USGS team's calculations, based on geologic and geodetic evidence, suggest that the next great quake won't be this century: the return interval of magnitude 8 quakes along the northern part of the San Andreas fault is between 130 and 190 years, they estimate.—*BTR*

Energy Predictions

The course of action in energy and science policy is exceedingly unclear now that the pervasive 'free market' philosophy of the Reagan administration conflicts with past practices, but a number of new revelations about the fundamentals of strategic minerals are emerging. For example, estimates of the energy demand projected for the United States to the year 2000 have suddenly been scaled downward by about 20% in numerous published reports. The Department of Energy recently revised its Year 2000 Energy Demand downward by 20 Quads, to 102 Quads (1 Quad = 10^{15} BTU, which multiplied by 252 equals calories). Other estimates within and outside of the federal government range as low as about 60 Quads for the demand in 2000.

This outcome makes it apparent that while there is new optimism about obtaining solutions to the energy and resource problems, the solutions may not be those proposed by the administration to increase supply. Conservationists are entering the fray with studies and estimates of their own, as witnessed by recent reports by the National Audubon Society, the Mellon Institute, and many other groups.

Historically, the inertial swings of supply and demand of resources have been damped by increased productivity, with or without the support of the federal government. A good example was described recently by P. J. Kakela, in a paper titled 'Iron Ore: From Depletion To Abundance' (*Science, 212,* 132–136, 1981). Kakela quotes a passage from the December 1945 issue of *Fortune* magazine about the World War II depletion of iron ore reserves in the Mesabi Range:

> Out of this tiny strip the steel-age economy has sucked like milk from the earth mother's breast, by far the largest portion of the principal food out of which its bones and muscles have been built: its machines and tools, its buildings and bridges, its railroads and automobiles and generating plants. Blasted and gouged from the strip's awesome open pits and scattered underground mines came a full two-thirds of the iron ore for the 400-odd million tons of steel out of which the U.S. fashioned the war plants, ships, planes, tanks, guns, bombs, and shells of World War II.

In projections for these final two decades of the 20th century, iron is not even listed with the strategic minerals in critical supply (aside from fossil fuel mineral resources, nonfuel reserves of the ores of Ti, Cr, Mn, Co, and Pt are considered in critical supply and the supply is vulnerable—*Science, 212,* 304, 1981). The point is that supply was considered the driving factor. The Reagan administration's approach to the energy problem is similarly focused on increasing the supply to meet the growing demand, but of course the Reagan plans include only the free-market influence without government assistance; particularly without regulation. Now, the picture of the U.S. energy demand appears to be very different than it was even a few months ago. More careful analyses from many sources suggest that total demand will be reduced steadily through the next two decades by conservation, especially by improved efficiency of converting fossil fuels to usable heat and energy, and by the improved development of renewable energy sources. New terms such as 'low-energy policy' are being used widely. For example, L. Emleer states

> . . . least-cost strategy . . . you'll be hearing that phrase more often. The . . . well-crafted studies are making remarkable inroads into traditional thinking on energy matters. Even Reagan's insider, Office of Management and Budget director David Stockman, enamored with well-turned phrases has sprinkled "least-cost strategy" through some recent speeches. And big oil companies, more enamored with the bottom line than the clever phrase, also have begun to pay heed. . . . [*Chem. Eng. News,* April 20, 1981].

The free marketplace affects the supply, and by allowing prices to float to high levels it also lowers demand. The supply will be supported for the short run by new exploration (*U. S. Geol. Surv. Open-File Rep. 81–92,* 1981). For the longer term, the lowering of demand offers a new, unexpected way out of the dilemma. Part of the reason the low-cost, low-energy predictions have met a favorable response lately is that the demand, as judged by the gasoline, has begun what could be a long-term decline in the United States and elsewhere. Improved efficiency already begun to affect the transportation sector, and it is not unrealistic to expect that it will affect heating and cooling and electrical generation plants.

According to reports cited by R. A. Kerr in *Science,* 212, 427–429, 1981), both pure statistical and geological estimates of the oil yet to be found in the United States are optimistic. The uncertainty of the estimates made by the U.S. Geological Survey is high. The estimates are long-range guesses based on subjective methods, and thus [illegible] geophysics community [illegible] this means that increased [illegible] and exploration will be continued for a long time [illegible]. The renewable energy resources such as hydro, solar, wind, geothermal, breeder-reactor, fusion/nuclear, and even biomass have been downgraded for the short term but now appear to have gained validity as prospects for the long term. In each instance, significant technology gains are required to bring the renewables on-line (except for hydro), but predictions now are that the gains will be made. In most instances the increases in supply of renewable energy resources over the next 20 years are expected to be on the order of 300% of what they are today.—*PMB*

OSCAR: The Acid Rain Project

The Environmental Protection Agency and the Department of Energy are jointly undertaking a project to evaluate the causes and effects of precipitation caused by coal smoke in the atmosphere. OSCAR (oxidation and scavenging characteristics of April rain; *Chem. Eng. News,* April 20, 1981, p. 26) is the acronym for a program to track acid rain from its origin to downwind locations. Several aircraft and several tens of precipitation samplers are located throughout North America to collect data.

The study is concentrated in an area near Ft. Wayne, Ind., an area in a strategic position to receive emissions dissolved and otherwise incorporated in rain thought to originate from the coal-burning plants in the Ohio river valley region. Other sites to be sampled are in the eastern United States and in Canada. If the plants do indeed contribute to the acid condition, this study will document the effect.—*PMB*

Lunar Rocks Available for Study

Lunar rocks and soil samples have been made available for scientific examination and for educational study to reseachers other than the selected few that NASA supports as part of its primary mission analysis. Universities may now obtain on loan exquisite sets of the Apollo samples simply by asking. The sets consist of thin-section mounts from the lunar sample collection and, as such, constitute valuable pieces of a national treasure. The loan of these sections carries an unusual responsibility, which is also an unusual opportunity.

The 12 thin sections of each set are from six rocks and four soils selected to provide a reasonable sampling of the range of materials returned from the moon. A guidebook accompanies the thin sections and provides a brief introduction to lunar surface features, lunar rock types, and lunar minerals; it also contains a lunar bibliography. The guidebook also describes the thin sections, relates them to the rocks or soils they represent, and attempts to fit them into a broad picture of the moon's evolution, what we have learned of it, and what unsolved problems remain.

There are two thin sections of mare basalts: one is low in TiO_2 and is porphyritic, with phenocrysts of olivine and pyroxene; the other is high in TiO_2 and coarse-grained, with a substantial amount of ilmenite. There is one thin section of a lunar plutonic rock: an anorthosite that has been crushed to form a cataclastic texture. There are three thin sections of polymict breccias that result from the fragmentation, mixing, and heating associated with impacts on the lunar surface. Breccias like these comprise the bulk of the rocks that occur in the heavily cratered lunar highlands. The three breccias represent the range of matrix textures that develop from impacts: one contains glass in the matrix; a second contains a fine-grained, igneous-textured matrix typical of crystallization from impact-melts; and the third contains an equant, granular-textured matrix typical of crystallization in the solid state. Clasts in these breccias represent basalts, plutonic rocks, and other breccias.

There are six thin sections of lunar soil, chosen to display several features. Two thin sections are of one grain-size fraction of two highland soils. One soil is mature and rich in agglutinates and the other soil is immature and poor in agglutinales. Three thin sections are of different grain size fractions from one mare soil. A range of glass, lithic, and mineral fragments occur in these five sections, which taken together illustrate differences between highland and mare soils as well as variations in components among different grain-size fractions of a single soil. The final thin section is of orange glass, an example of a lunar pyroclastic deposit.

There are 32 sets of thin sections available for distribution to educational institutions. At present it is possible to obtain the thin-section packages for reasonable lengths of time at nearly any time period that is convenient for one's class schedule. Information on the thin-section educational package or the lunar sample program in general can be obtained by writing to Lunar Thin Section Educational Program, Office of the Curator, SN2, NASA Johnson Space Center, Houston, TX 77058 or by calling (713) 483-3274.—*PMB*

Fulbright Award Opportunities

More than a dozen opportunities are available to geophysicists in the 1982–1983 Fulbright Awards program for United States scholars to study abroad. The lecturing and research awards are listed in a new brochure published by the Council for International Exchange of Scholars. Geophysics-related opportunities are also available in geography, engineering, and technology.

The majority of grants are for the academic year in the host country. All are subject to availability of funds and changes in program priorities.

The deadline for applications for positions in the American republics, Australia, and New Zealand is June 1; deadline for positions in Africa, Asia, and Europe is July 1. Applicants must be U.S. citizens at the time of application.

For a copy of the brochure, write the Council for International Exchange of Scholars, 11 Dupont Circle, N.W., Suite 300, Washington, D.C. 20036.

AGID Gets New Home

The Association of Geoscientists for International Development (AGID), in February, opened new global headquarters at the Asian Institute of Technology (AIT) in Bangkok, Thailand. Prinya Nutalaya is AGID's president.

Housed in AIT's geotechnical division, AGID leaves its old home in Caracas, Venezuela. The former secretariat, under the direction of Alirio Bellizzia, now operates as a regional office for Latin America and the Caribbean. A new regional office for Africa also has been established at Ahmadu Bello University in Nigeria.

Inquiries about AGID should be addressed to headquarters: AGID, Asian Institute of Technology, Box 2754, Bangkok, Thailand.

NASA, NOAA Administrators Nominated

President Ronald Reagan recently said he intended to nominate James Montgomery Beggs as NASA Administrator and John V. Byrne as NOAA Administrator. These two positions are key scientific posts that have been vacant since the start of the Reagan administration on January 20. The President also said he intends to nominate Hans Mark as NASA Deputy Administrator. At press time, Reagan had not designated his nominee for the director of the Office of Science and Technology Policy.

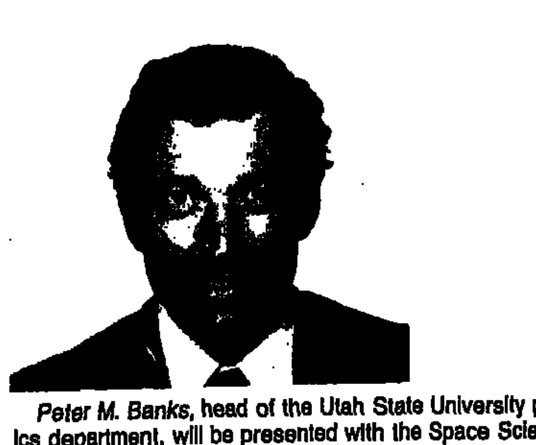
The nominations must receive approval from Capitol Hill before they become effective. This process can take up to several weeks.

Beggs has been executive vice president for aerospace and a director of the General Dynamics Corp. in St. Louis, Mo. He served with NASA in 1968–1969 as associate administrator for the Office of Advanced Research and Technology. From 1969 to 1973, he was Undersecretary of Transportation. He went to Summa Corp. as managing director of operations and then joined General Dynamics in January 1974. Before joining NASA, he had been with Westinghouse Electric Corp. for 13 years. If confirmed, Beggs will succeed Robert Frosch.

Byrne has held various positions at Oregon State University since 1960. He was professor and chairman of the oceanography department from 1968 until 1972, when he became the dean of the School of Oceanography. He was acting director of the Marine Science Center for 5 years until 1977. He was the dean for research from 1977 through 1980. He has been the vice president for research and graduate studies since 1980. Byrne also was program director for physical oceanography from 1966–1967 at the National Science Foundation. If confirmed, Byrne will succeed Richard Frank.

Mark, Reagan's nominee for NASA Deputy Administrator, served as Secretary of the Air Force from July 1979 to 1981. He had served as undersecretary since 1977. He was chairman of the nuclear engineering department at the University of California at Berkeley and administrator of the Berkeley Research Reactor from 1964 to 1969. He joined the Ames Research Center in 1969. —*BTR*

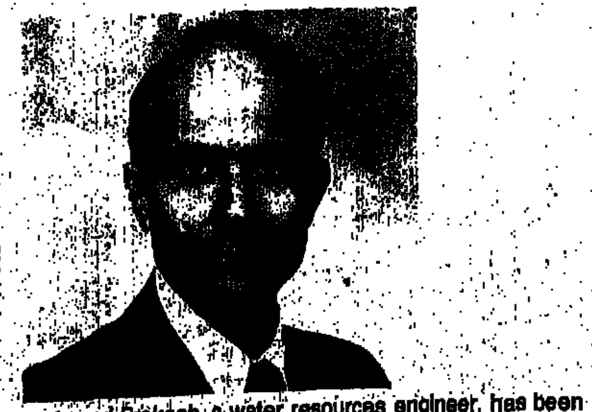
Geophysicists



Peter M. Banks, head of the Utah State University physics department, will be presented with the Space Science Award of the American Institute of Aeronautics and Astronautics.

Edward S. Epstein has been appointed director of the Environmental Sciences Laboratory of the National Earth Satellite Service. Epstein had directed the National Climate Program office within the Department of Commerce since 1978.

John N. Howard retired in late March after 17 years as chief scientist of the Air Force Geophysics Laboratory at the Hanscom Air Force Base in Massachusetts. He will continue to work half-time as senior scientist at Hanscom for approximately 1 year.



Anand Prakash, a water resources engineer, has been appointed a senior engineer at the Dames & Moore Denver office. He joined the firm in 1980. Prakash's most recent project was an investigation of alternative rehabilitation methods for the Rio Blanco hydropower plant in Puerto Rico.

Geophysical Events

This item comprises selected reprints from *SEAN Bulletin, 6*(3), March 31, 1981, a publication of the Smithsonian Institution.

Volcanic Activity

Mount St. Helens Volcano, Cascade Range, southern Washington, USA (46.20°N, 122.18°W). All times are local (GMT–8 h). March eruptive activity from Mt. St. Helens was limited to occasional emission of small steam clouds, at least one of which contained ash. However, significant deformation was measured within the crater, and there was a slight increase in volcanic seismicity during the second half of March. Geologists announced that another eruptive episode was likely if the deformation and seismic trends continued, but none had occurred by *SEAN*'s April 8 press time.

The U.S. Geological Survey-University of Washington seismic net recorded 15 bursts of seismicity in March and five more bursts during the first 6 days of April. In the past, similar signals have often been correlated with episodes of steam emission, but because of poor weather, correlations with only two such episodes could be confirmed in March: a minor puff on March 9 at 1549, and a steam cloud containing some ash on March 27 at 1441. Newly fallen ash (made up of reworked dome material) observed NE of the volcano March 25 may have been ejected during a burst of seismicity the previous day.

The seismic net began to detect small, low-frequency, shallow events on Mt. St. Helens on March 21. Fifteen of these discrete volcanic events were recorded by the end of March. Numerous aftershocks of the magnitude 5.5 tectonic event, which occurred February 13 about 12 km N of Mt. St. Helens, continued to appear on seismic records through March.

Deformation measurements showed that outward movement of the N crater rampart resumed in March. Between March 9 and 17, the rampart moved 7 cm to the N; by March 22 it had advanced 6 cm farther northward; and an additional 3.5 cm of movement was measured March 24.

A newly established leveling net on the crater floor showed pronounced uplift near the lava dome, indicating that the dome was rising. Increasing crater floor deformation was also demonstrated by accelerations in the rate of widening of a fissure from 3 mm/d to 1 cm/d and the rate of movement of a thrust fault from $\frac{1}{2}$ cm/d to 1 cm/d by late March.

Addendum: On April 9 at about 1800, local seismicity began to increase to about one event per hour at first to about two per hour after midnight. The U.S. Geological Survey-University of Washington team issued an advisory about midnight, stating that an eruption was likely within the next day if seismicity continued to increase.

Periods of constant low-frequency seismicity became more frequent, and by 0230 on April 10, low-frequency activity was continuous. Individual events superimposed on this activity had increased to an average of six to eight per hour by 0600 and remained at this level through the day. At 0821, a small explosion produced an ash-bearing plume that rose to 4.5-km altitude. A light ashfall was reported at a ranger station 40 km to the NE. Although clouds prevented observation of the crater, a U.S. Geological Survey helicopter crew could see that this explosion had generated no pyroclastic flows.

About 1900, the pattern of seismic activity started to change. The number of discrete events dropped to four to six per hour, but these events were slightly stronger, and total seismic energy release briefly stayed about the same. However, by midnight there had been a notable decline in both the number of events and seismic energy release, and by 0200 only one to two events were being recorded per hour. Seismicity had essentially ended by 2100–2200 on April 11.

The weather cleared somewhat late April 12, and geologists were able to view the crater between 1800 and 1900. New lava extended roughly 75 m to the NNW from the preexisting dome (extruded in three episodes in October 1980, December 1980–January 1981, and February 1981). Television station videotape taken between 1900 and 1930 showed significant additional lava extrusion. Additional information on this episode will be presented next month.

Information contacts: Don Swanson, Chris Newhall, and Susan Russell-Robinson, U.S. Geological Survey Field Office, 301 E. McLaughlin, Vancouver, Washington 98663.

Christina Boyko, A. B. Adams, Steven Malone, Elliot Endo, and Craig Weaver, Graduate Program in Geophysics, University of Washington, Seattle, Washington 98195.

Robert Tilling, U.S. Geological Survey, Stop 906, National Center, Reston, Virginia 22092.

Etna Volcano, Sicily, Italy (37.73°N, 15.00°E). All times are local (GMT + 1 h). An eruption of Etna March 17–23 extruded lava from several fissures on the NNW flank. Initial estimates indicate that the main flow reached about 7.5 km in length, lava flows covered an area of about 6 km^2, and about 30–35 $\times 10^6$ m^3 of lava were extruded at a rate of 58–70 m^3/s. Damage was estimated at about $10 million. Of the 90 historic eruptions of Etna for which location data are available, only three (1614, 1764, and 1918) occurred on the NW or NNW flanks. A detailed description of the eruption follows.

Etna began to erupt on March 17, after a 2-day swarm of about 500 earthquakes, including a magnitude 4–5 event during the morning of March 16. On March 17, at 1337, an eruption fissure opened at about 2260 m above sea level on the NW flank (near point A, Figure 1), trending approximately NW–SE. Lava fountains rose 100–200 m from this fissure, and lava flowed rapidly westward. In the next 4 hours, three more fissures opened; the first and third also trending NW, the second WNW. All showed strong lava fountaining and were the source of lava flows. As fissures

(News cont. on page 478)

(News cont. from page 477)

formed at lower altitudes, those higher on the volcano ceased to be active.

At 1855 on March 17, another fissure opened at 1800-m elevation on the NNW flank (E of point B, Figure 1), trending NW at its upper end but after a short distance changing direction to more directly downslope. A large lava flow that originated from this fissure traveled 5 km within 4 hours, cut a railroad and highway (at about 730-m altitude) during the night, and crossed another railway line and road (at about 680-m altitude) early on March 18. The lava destroyed farm buildings and orchards and passed very close to the village of Montelaguardia, forcing the evacuation of its 250 residents. The fissure propagated downslope to about 1300-m altitude at 1130 on March 18. The lower section extruded a small lava flow that briefly threatened Randazzo (pop. 15,000) but did not force its evacuation. By 1630, the center of the main flow was more than 1 km wide, and its front had reached 650-m altitude, about 100 m from the bed of the Alcantara River.

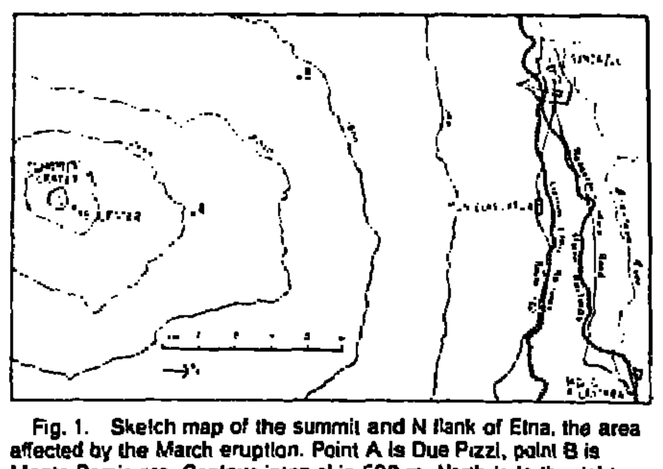


Fig. 1. Sketch map of the summit and N flank of Etna, the area affected by the March eruption. Point A is Due Pizzi, point B is Monte Pomiciaro. Contour interval is 500 m. North is to the right. The map was prepared from Carta Geologica del Monte Etna (1979), Istituto Internazionale di Vulcanologia, Catania, Italy.

Another fissure opened between 1235- and 1140-m altitude at 2200 hours, extruding flows that moved toward Randazzo. By this time, the system of eruption fissures had a total length of about 7.5 km. The main flow reached the Alcantara River bed (600 m above sea level) on March 19 at 1100, while the flows extruded from the fissure between 1235- and 1140-m altitude continued to advance slowly. By noon on March 20, this fissure was characterized by mild spatter ejection that continued to feed slow-moving lava flows. However, the main flow had nearly halted. Sporadic activity between 1235 and 1140 m continued March 21–22, finally ending during the evening of the 23rd. The longest flow from this fissure stopped at 900-m elevation, about 2 km from Randazzo. More than 25 small earthquakes centered around the eruption fissures were recorded on March 23.

Throughout the period of lava extrusion, more-or-less intense emission of sand-size tephra occurred from the central crater's W vent, enlarging this vent to the W. Strong winds caused ashfalls on the N flank March 22.

Information contacts: Romolo Romano, Istituto Internazionale di Vulcanologia, Viale Regina Margherita 6, 95123 Catania, Italy.

United Press International.

The Associated Press.

Piton de la Fournaise Volcano, Réunion Island, Indian Ocean (21.23°S, 55.71°E). All times are local (GMT + 4 h). The eruption SW of the summit that began February 28 continued until March 25–26.

A new eruption on April 1 was preceded by a swarm of local earthquakes, starting at 1923. The seismographs at Réunion's volcano observatory registered 72 discrete events in the few hours before the onset of harmonic tremor and the start of an eruption at 2141. Observatory per-

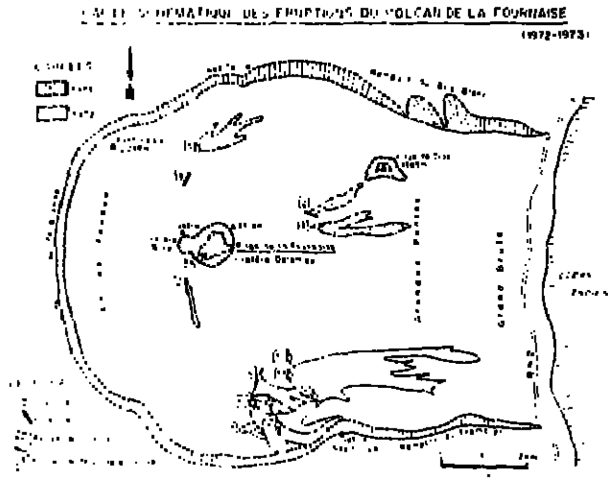


Fig. 2. Map of the caldera of Piton de La Fournaise, from Krafft, M., and Gerente, A., L'activité de Piton de la Fournaise entre octobre 1972 et mai 1973; *C. R. Acad. Sci. Paris, Serie D., 284,* 607–610, 1977. The lava flow of April 1–2 traveled approximately the route shown by the arrow. Lava extruded from the vent at A reached B during the night of April 1–2 and about point C by the afternoon of April 2.

sonnel reported that lava extruded from a vent in the north central area of the caldera (point A on Figure 2) about 3 km ENE of the summit, flowed toward the N caldera wall, and reached point B during the night. By the early afternoon of April 2, the flow front was at point C, at 300-m altitude and about 1 km W of the coast highway (R.N. 2), but the lava's rate of advance had slowed considerably.

Information contacts: J. L. Le Mouel and J. L. Cheminee, Institut de Physique du Globe de Paris, Direction des Observatoires Volcanologiques, 4 Place Jussieu, 75230 Paris Cedex 05, France.

Hekla Volcano, southern Iceland (63.98°N, 19.70°W). Karl Grönvold provided the following preliminary information at press time. A more complete report will appear next month.

Ash ejection from Hekla began just before 0300 on April 9. Pilots said that ash reached 4.2-km altitude and radar registered the top of an eruption column at 6.6 km above sea level. Ash blew to the N, toward the interior of Iceland, falling at least 30 km from the volcano. No unusual seismic activity was recorded by the nearest seismograph, about 30 km away, until about 18 hours after ash ejection began. Ash emission had ended by the next morning, but poor weather prevented an exact determination of the stop time.

Lava extrusion from craters near the summit was first seen during the afternoon of April 9. Lava flowed to the NE and SW. As of April 10, extrusion of lava was continuing, but the volume of lava was orders of magnitude less than in August 1980. Volcanologists considered the April activity to be a continuation of the much larger August eruption, a typical pattern of behavior at Hekla.

Information contact: Karl Grönvold, Nordic Volcanological Institute, University of Iceland, Reykjavik, Iceland.

Krafla Caldera, Mývatn Area, Iceland (65.71°N, 16.75°W). The following is a report from Karl Grönvold.

As of 2 April, land elevation over the Krafla magma reservoirs, as indicated by tiltmeters, was about the same as at the time of the eruption that began 30 January. Inflation continued and from past experience an eruption can be expected to take place in the near future, possibly within the next few weeks.

Information contact: Karl Grönvold, Nordic Volcanological Institute, University of Iceland, Reykjavik, Iceland.

Kavachi Volcano, Solomon Islands, SW Pacific (9.03°S, 157.93°E). All times are local (GMT + 11 h). Solair Captain Peter Cox overflew Kavachi on January 9, at 1540. At 30- to 60-min intervals, steam fountains rose to a height he estimated at 150 m. The sea was stained light brown for as much as 15–20 km from the volcano, but Captain Cox saw no floating pumice.

A. Smith, a Ministry of Natural Resources geologist, observed minor eruptive activity at Kavachi on February 25. Submarine explosions, apparently originating at 5–10 m depth, transmitted shock waves to the surface. Some gas bubbles could be seen, but no ejecta were evident. The prevailing wind drove seas to the NE, carrying an expanding plume of yellow-brown to yellow-green water visible on the surface for at least 2 km from the volcano.

Submarine activity at Kavachi was observed on several occasions between early October and early December 1980. Kavachi's last eruption, June–July 1978, produced a small ephemeral island, its eighth island-forming eruption since 1950.

Information contact: Deni Tuni, Geological Division, Ministry of Natural Resources, Honiara, Solomon Islands.

Semeru Volcano, Java, Indonesia (8.11°S, 112.92°E). All times are local (GMT + 7 h). Dome extrusion at Semeru has continued since 1967. Frequent lava avalanches and small ash ejections were reported in late 1980.

Activity increased March 28. The first nuée ardente moved about 4 km from the summit down the Kembar and Kobokan rivers (on the S flank) at 1755. During the following days, increasingly intense nuées ardentes reached a distance of more than 7 km from the summit. Four nuées ardentes and 19 lava avalanches (presumably accompanied by nuées ardentes of eruptive origin) were reported on March 29, and four more nuées ardentes and 36 lava avalanches were observed the next day. As of 31 March, tremors were being continuously recorded by the Volcanological Survey of Indonesia seismograph, about 10 km from the summit.

One person was killed by a nuée ardente and 272 others were evacuated. The ongoing rainy season may cause lahars and associated flooding.

Information contacts: A. Sudradjat, Director, and L. Pardyanto, Senior Volcanologist, Volcanological Survey of Indonesia, Diponegoro 57, Bandung, Indonesia.

Bagana Volcano, Bougainville Island, Solomon Islands, Southwest Pacific (6.14°S, 155.19°E). The following is a report from the acting senior volcanologist.

Moderate to strong emission of white vapour continued throughout March. An active lava flow descending the N slope had reached two thirds of the way down the mountain. Small nuée-ardente-type avalanches caused by collapse of the flow front were observed during an aerial inspection on 9 January.

Bagana's eruption began in 1972.

Information contact: Acting Senior Volcanologist, Rabaul Observatory, P.O. Box 386, Rabaul, Papua New Guinea.

Kadovar Volcano, off the north coast of New Guinea (3.62°S, 144.62°E). The following is a report from the acting senior volcanologist.

An area of orange discolouration of the sea at the NE shore was observed during aerial inspections on 6 and 19 March. Previously (1976–7), sea discolouration was present at the S shore and was related to the development of a new thermal area on the S flank of the island. This thermal area was now observed to have been reduced in size by regrowth of vegetation.

Information contact: Same as for Bagana.

Bam Volcano, off the north coast of New Guinea (3.60°S, 144.85°E). The acting senior volcanologist reports that during aerial inspections March 6 and 19 a 1-km-long zone of orange discoloration of the sea was noted at the S shore of Bam Island. Bam's last eruption in 1960 consisted of explosions from the central crater.

Information contacts: Same as for Bagana.

Karkar Volcano, off the north coast of New Guinea (4.65°S, 145.96°E). The following is a report from the acting senior volcanologist.

Aerial and ground inspections of Karkar were made 6–8 March and other aerial inspections were carried out on 19 and 26 March. Conditions in the caldera appeared to be similar to those observed during previous inspections in November and December 1980. Hydrothermal activity was continuing at the base of the 1979 crater, and maximum measured temperatures were 97.5°C. Apart from vapour sources in the 1979 crater, the other main source was on the W part of Bagiai Cone. During the aerial inspection on March 26, the volume of emission was reportedly greater than previously observed.

Gravity measurements and levelling were carried out at Karkar 6–8 March. The gravity measurements were consistent with previous sets in 1980, and might indicate summit deflation. Levelling up to the end of 1980 showed possible small deflationary trends of several microradians at the three mid- and upper-flank tilt arrays. However the changes were very small and similar in size to the limits of error in making the measurements.

Karkar began an explosive eruption in January 1979. Two volcanologists were killed in March 1979 by an explosion from the SE foot of Bagiai Cone.

Information contact: Same as for Bagana.

Langila Volcano, New Britain Island, Papua New Guinea (5.53°S, 148.42°E). The following is a report from the acting senior volcanologist.

The first 3 months of 1981 have shown a steady decline of eruptive activity at Langila. Occasional brown ash-laden emissions from Crater 2 were observed in January, but in February and March the emissions from Crater 2 were white and apparently of declining volume. Crater 3 released blue and white vapours in January and February; in March only small volumes of white vapour were emitted. The last time glow was observed was on 21 January from Crater 2.

Seismic activity from Langila was at a low level during the period January–March. Small tremorlike signals continued to be recorded.

Langila has been active since 1973.

Information contact: Same as for Bagana.

Manam Volcano, off the north coast of New Guinea (4.10°S, 145.06°E). The following is a report from the acting senior volcanologist.

During the first 2 months of 1981, a low level of activity prevailed at Manam. White and occasionally brown emissions were observed from both craters. In March, moderate-to-strong brown and light grey ash-laden emissions were common from the S crater. The main crater emissions were also grey on several occasions. Explosive sounds from the summit were rarely heard in January and February but became noticeable in the second half of March. Night observations of the volcano in January and February indicated no instances of lava fragment ejections above the craters, although weak glow above the S crater was reported for 2 January. Sparse ejections of lava fragments from the crater were observed overnight on 14–15 March, and glow above the S crater was observed on 30 March.

Background volcano-seismic levels remained fairly steady January–March, but a significant change in seismic activity was the occurrence of strong local earthquakes, possibly of volcanic origin. Preliminary analysis of seismic records showed that five such events were recorded in February and 14 in March.

The tiltmeters at Manam continued to show a trend of northerly uplift. After the last major eruptive period in 1974, a pattern of summit deflation prevailed until early 1978. The total amount of deflation was about 14 microradians. A definite trend of inflation began in the second half of 1979. The accumulated tilt during the last 2 years was about 6 microradians.

Aerial inspections were made at Manam on 6 and 19 March. Cloud cover prevented detailed observations of summit activity on 6 March, but a distinct blue vapour haze was present drifting down the N and NW flank of the volcano. On 19 March, brown ash-laden ejections from the S vent were occurring at about half-minute intervals. The main vent continuously released white vapours. Again a blue vapour haze was present, extending about 1 km to the N of the summit.

Information contact: Same as for Bagana.

Tarumai Volcano, Hokkaido, Japan (48.68°N, 141.38°E). Local seismicity began to increase in November 1980, and the number of events per month reached 1211 in February 1981 (see Figure 3). Seismicity began a gradual decline in early March and by mid-March had reached the usual average of fewer than three recorded earthquakes per day.

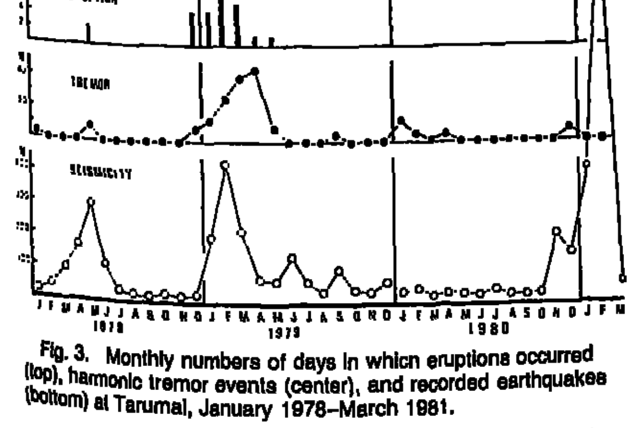


Fig. 3. Monthly numbers of days in which eruptions occurred (top), harmonic tremor events (center), and recorded earthquakes (bottom) at Tarumai, January 1978–March 1981.

Only 87 events were recorded in March. Although the December 1978 to May 1979 eruption accompanied the last major increase in seismicity, no eruption has occurred during the current, much larger, increase.

Information contact: Seismological Division, Japan Meteorological Agency, 1-3-4 Otemachi, Chiyoda-ku, Tokyo 100, Japan.

Kirisima Volcano, Kyushu, Japan (31.88°N, 130.92°E). Fumarolic activity had increased since November 1980 in the Iodani ('Sulfur Valley') area at the W base of the volcano. Personnel from Kagoshima and Tokyo universities, Tokyo Industrial College, and the Japan Meteorological Agency's (JMA) observatory monitored the temperatures and the chemical composition of the vapor. The highest temperature measured was 98° C in March, the same as was measured during the past 2 years. The gas content varied from 90% CO_2–10% H_2S to 70% CO_2–30% H_2S.

New fumaroles appeared in a residential area. Because of the dense gas, civil defense police closed a parking area and part of a road. Landslides from Kirisima killed 16 persons in 1942, 34 in 1949, and 9 in 1954. Major landslides in 1959 and 1971 accompanied weak phreatic explosions in the geothermal area, but there were no casualties. In April 1979, JMA personnel discovered a 50-m-long 10-cm-wide sulfur flow that had come from a fumarole in the SE part of the Kirisima complex.

Information contact: Same as for Tarumai.

Sakurazima Volcano, Kyushu, Japan (31.58°N, 130.65°E). Eleven explosions occurred in March at Sakurazima, active since 1955. The highest ash cloud grew to 2 km on the 18th. Two incandescent columns rose simultaneously from vents in the summit crater of Minamidake on the 20th. No damage was reported.

Explosions at Sakurazima, March 1981

Date	5	9	10	16	18	20	22	29	30	Total
Explosions	1	2	1	1	2	1	1	1	1	11

Information contact: Same as for Tarumai.

White Island Volcano, Bay of Plenty, New Zealand (37.50°S, 177.23°E). New Zealand Geological Survey (NZGS) personnel visited White Island on January 17 and March 6 and overflew the volcano on February 24, after reports of explosive eruptions in January.

During the January visit, a weakly convoluting gas column charged with light brown ash was issuing from the active vent in the S part of the 1978 Crater (on the W side of the main crater). Gray tephra covered the main crater floor. Since the magmatic activity in early November, about 500 mm of ash had been deposited near the rim of 1978 Crater. Of this total, about 230 mm had been deposited since the last ground inspection on December 2. Two or possibly three generations of impact craters, the youngest of which may have been less than a day or two old, were found in the area 250–600 m NE of the active vent, with concentrations of up to three craters per m^2 300–400 m away. Crater diameters ranged from 30 mm to 1.2 m. Blocks up to 0.7 m in diameter were found in some of the impact craters, but no fresh magma appeared to have been ejected. The apparent near-vertical final trajectory of the blocks occupying the impact craters was striking.

Seismic records showed that periods of high-frequency tremor occurred January 7–13, 17–19, 22–23, 25–28, and January 30–February 11. Short bursts of harmonic tremor were recorded after the high-frequency tremor declined. Large discrete events (eruption sequences) were recorded on January 24 and 29 and February 6, 12, 17, 23, and 24. The eruption accompanying the January 24 event produced ashfall at Cape Runaway (75 km E of White Island, on the mainland) and was witnessed by P. M. Otway (NZGS).

So little gas and tephra were being emitted during the February 24 overflight that viewing was excellent. The main crater floor appeared to be covered by a thick layer of red-brown, *principally fine-grained*, tephra. Impact craters made since the January 17 visit pocked the floor as far as 600 m E of the active vent, the greatest range since the March 1977 eruptions.

On March 6 emissions from the active vent, then entrenched in a subcrater at least 200 m deep, were very low. The rim of 1978 Crater showed no major changes, but a large portion of the crater floor N of the active vent had been raised several m by rapid accumulation of tephra between the January 17 visit and the February 24 overflight. At the E edge of 1978 Crater rim, 410 mm of new tephra overlay earlier deposits. Within a km to the E the new tephra thinned to about 8 mm. The surface layer was a fine pink ash (mean diameter about 63 μ) containing abundant lithic clasts, subordinate crystals of pyroxene and olivine, and minor amounts of glassy weakly-to-moderately vesicular essential low-silica andesite. This layer was underlain by a finer green ash containing a greater percentage of essential clasts.

A few new impact craters had formed just outside 1978 Crater's E rim, some occupied by lithic blocks that were not coated with ash. Some of the older impact craters scattered across the main crater floor contained buried scoriaceous bombs, apparently of recent magmatic origin.

Fumaroles checked from the air in February were monitored in March. The inspection team measured minimum temperatures of 490°–650° C at three fumaroles that had formed within the past year E of 1978 Crater rim, one of which is the most energetic feature on the island other than the active vent.

The March leveling survey showed that subsidence had continued after the previous survey on December 2. The volcano had deflated about 300 microradians since last May, the peak of a 6-month period of inflation (see Figure 4). The greatest deformation, 12–13 mm since December and a total of 60 mm since May, was about in the center of the main crater, near the zone of fumarolic activity just E of 1978 Crater.

Information contact: B. J. Scott, B. F. Houghton, and I. A Nairn, New Zealand Geological Survey, P.O. Box 499, Rotorua, New Zealand.

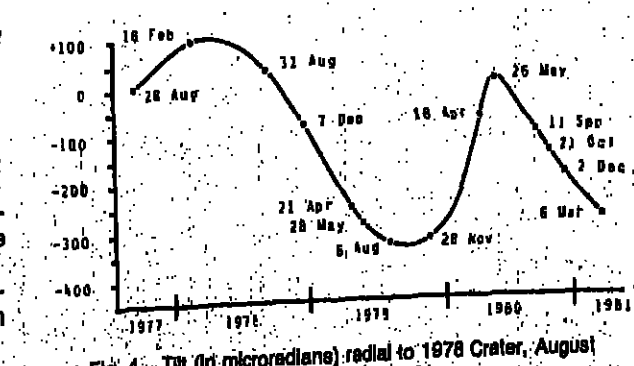


Fig. 4. Tilt (in microradians) radial to 1978 Crater, August 1977–March 1981.

Pacaya Volcano, southern Guatemala (14.38°N, 90.60°W). All times are local (GMT − 6 h). Newspapers reported that vigorous magmatic activity began at Pacaya on February 9. When geologists climbed the volcano February 14, lava filled much of MacKenney Crater, high on the WNW flank, and small lava fountains emerged from two coalesced spatter vents. According to newspapers, activity peaked February 18 at 1730 as lava overflowed the N rim of the crater and began to move down Pacaya's N flank.

Michigan Technological University geologists climbed Pacaya again on March 5. Since their last visit February 14, the level of the lava lake in MacKenney Crater had risen considerably, the two coalesced spatter vents had grown, and an additional small spatter vent had formed in the S part of the crater on the lava lake surface. The new S vent continuously extruded two pahoehoe lava flows but was not the source of any strombolian explosions. A few small pahoehoe flows were also moving across the E side of the crusted lava lake surface. Nearly continuous weak strombolian activity occurred from the two older vents. The smaller N vent had many small strombolian explosions at intervals of 10–20 s. From the larger vent activity was cyclical, consisting of a 1–5-s explosion that ejected spatter to 200–300 m above the vent, followed almost instantly by a large increase in gas emission that peaked in about 1 min, decreased slowly, then dropped sharply about 30 s before the next explosion. Gases above the vent had an intense blue color. The alignment of the three vents in MacKenney Crater indicated that the activity may have been from a fissure trending approximately N–S.

The geologists estimated that the lava flow descending the N flank had a volume of about 2×10^4 m^3 on March 5. They estimated the total volume of 1981 lava at about 1×10^6 m^3, for an average eruption rate of about 4×10^4 m^3/d. The lava was petrologically similar to lavas from eruptions since 1970, consisting of basalt with abundant plagioclase phenocrysts and sparse olivine phenocrysts.

Information contacts: Theodore J. Bornhorst and Craig A. Chesner, Department of Geology and Geological Engineering, Michigan Technological University, Houghton, Michigan 49931 USA.

Santiaguito Dome, western Guatemala (14.76°N, 91.55°W). All times are local (GMT − 6 h). On several occasions between February 17 and March 2, R. W. Hodder and a group of students observed explosive activity at Santiaguito Dome, a dacite complex that has been growing on the SW flank of Santa Maria volcano since 1922. They saw morning eruptions from Caliente Vent, at the E end of the dome, on February 17, 23, 24, 26, 27, and 28, and March 2, and late afternoon eruptions on February 17 and March 2.

The group climbed Santiaguito on February 23 and 24. During one eruption accretionary lapilli fell, followed by raindrops coated with fine ash.

About 1000 on February 26, a large 30-min eruption of gas with very little ash occurred from Caliente Vent. The eruption column rose to about 1800 m, reaching a diameter of about 500 m (much larger than any other observed by Hodder's group) and forming a well-developed anvil-shaped top. At its maximum the upper ¼ of the column was ash-poor nearly white vapor, while the lower ¾ darkened downward to a light brown (lighter colored than the February 12 eruption column).

The group saw eruptions at 1000 and 1115 on February 28 during 5 hours of observations. The first consisted of a single 10-min pulse that sent a vapor column to about 500 m above the vent. The second comprised four pulses in 30 min. Each pulse began with a white-topped column that developed a light-tan base and an anvil-shaped top as it rose as much as 1500 m above the vent. Between each pulse there was intense fuming.

Dartmouth College scientists climbed to the summit of Santa María on the morning of March 24. They provided the following report.

The plug dome previously observed in the crater of Caliente Vent was clearly visible and appeared to be covered with huge blocks of light gray lava. Four eruptions occurred within 3 hours with repose periods of 20 minutes, 1 hour, and 1 hour 40 minutes. Each was ash-rich and clearly audible from the summit (a distance of 2.8 km). They all rose in the gas-thrust phase to approximately the elevation of the summit (a vertical distance of 1272 m) and beyond, convectively.

Avalanches in the crater and down the SW flank occurred every 5–15 minutes, suggesting nearly continuous activity of the dome. The several hundred m long lava flow, visible on the SW flank in February 1980, was not visible from the summit, but avalanche clouds rising from that area suggest that it is still active there.

One large fumarole in the NW part of the plug dome was continuously and very vigorously degassing, remaining essentially unchanged even during eruptions. All four eruptions began in the NE and E region of the crater and lasted 2–4 minutes.

Information contacts: R. W. Hodder, Department of Geology, University of Western Ontario, London, Ontario, Canada N6A 5B7.

Theodore J. Bornhorst, Craig A. Chesner, and William I. Rose, Jr., Department of Geology and Geological Engineering, Michigan Technological University, Houghton, Michigan 49931 USA.

Stanley N. Williams, Department of Earth Sciences, Dartmouth College, Hanover, New Hampshire 03755 USA.

Mona A. Mort, Department of Biological Sciences, Dartmouth College, Hanover, New Hampshire 03755 USA.

Fuego and Acatenango Volcanos, Guatemala (14.48°N, 90.88°W and 14.50°N, 90.87°W). On February 16, 17, and 18 geologists visited the summits of Fuego and Acatenango volcanos.

Comparisons of photographs of Fuego taken on this expedition to ones taken by W. I. Rose, Jr., in February 1980 showed no striking physical changes in the summit region. The main areas of gas emission, on the N and the SE sides of the main crater, were the same as in 1980. (The SE area is a spatter vent from Fuego's last eruption in 1977–1979.) During the group's visit, gas was being emitted at a moderate steady rate, as in early 1980. On February 21, however, the group observed that there was a clear pulsation in the rate of emission, with a period of about 2 min. A light wind on the 21st allowed the gas plume to rise nearly vertically about 400 m above the crater. Around the crater rim there were only a few fumaroles in contrast to many in early 1980. New fumaroles had appeared around and atop an older irregular domal protrusion on the W flank of the summit.

At Acatenango there was no visible fumarolic activity around the summit or in the explosion craters from the volcano's last eruption in 1972. The geologists smelled a strong sulfur odor in the immediate vicinity of the summit craters.

Information contact: Theodore J. Bornhorst and Craig E. Chesner, Department of Geology and Geological Engineering, Michigan Technological University, Houghton, Michigan 49931 USA.

Volcanic Activity in Nicaragua, February–March 1981. The following is a report from Stanley N. Williams and Richard E. Stoiber.

Scientists from Dartmouth College, the Nicaraguan Institute of Natural Resources and the Environment, and the Nicaraguan Institute of Seismological Investigations report the following based on their continuing cooperative observation of Nicaraguan volcanoes.

Masaya (11.95°N, 86.15°W). The fourth gas emission crisis of this century continues unabated. Extensive remote measurement of SO_2 output (by COSPEC) has revealed a greater variability in emission rates than had previously been recognized (several hundred to several thousand tons per day). The pit crater from which the gas is emitted continues to increase slowly in diameter and is strongly elongate in the NW–SE direction. Night observation of the activity was possible and confirmed the complete absence of any incandescence in the pit where lava was visible as recently as November 1978.

Telica (12.60°N, 86.87°W). Two flights were made over the summit crater of Telica, in mid-February and mid-March. Two large holes (each with a diameter of approximately 20–30 m) occur high on the NW wall of the crater. They are reported (by Alain Creusot, Nicaraguan Institute of Energy) to coalesce at depth. One or both of them emit a continuous vapor plume. Occasional minor ash eruptions are reported by local people.

San Cristóbal (12.70°N, 87.02°W). A trend of decreasing SO_2 emissions had been evident since the small ash eruptions of March 1976. However, San Cristóbal has suddenly reversed this trend, after being in a heightened state of seismic activity since August 1980. In late February, SO_2 output increased by approximately an order of magnitude to the several thousand tons per day level of the mid-1970's. Flights over the crater in mid-February and mid-March showed evidence of considerable recent slumping in the crater formed by the eruptions of 1976, especially on the N and NW walls. Fumarolic activity was evident all over the crater but was most concentrated in the S and SE margins of the floor and in the lower parts of the walls. No new fumaroles or fissures were observed outside the 1976 crater. Night observation revealed extensive incandescence over much of the crater, even more than that observed in December at Momotombo. High gas concentrations and unstable footing prevented measurement of any fumarole temperatures. Seismic activity continued at high levels, with almost continuous harmonic tremor and at least one earthquake with magnitude greater than 2 (this occurred one week before the elevated SO_2 emission was detected).

Momotombo (12.42°N, 86.55°W). A small continuous plume continues to be released. No new measurements were made. No significant seismicity has occurred recently.

Cerro Negro (12.52°N, 86.73°W). A flight over the crater in mid-March revealed one area of minor fumarolic activity in the SW center region of the crater. No significant seismicity has occurred recently.

Information contacts: Stanley N. Williams and Richard E. Stoiber, Department of Earth Sciences, Dartmouth College, Hanover, New Hampshire 03755 USA.

Debbie Reid Jerez, Nicaraguan Institute of Natural Resources and the Environment, Managua, Nicaragua.

Douglas Fajardo, Nicaraguan Institute of Seismological Investigations, Managua, Nicaragua.

Poás Volcano, northwest of San José, Costa Rica (10.18°N, 84.22°W). Activity at Poás had increased, with explosions observed September 11 and December 26, 1980. As of mid-March, the Instituto Costarricense de Electricidad and the Universidad Nacional were keeping the volcano under continuous observation. The temperature of the dome in the crater lake was 650°–750° C, and some red areas were seen along fissures in the dome. Lake water temperatures were 50° C., similar to temperatures in the fall of 1980. The pH of the lake had decreased to 0.1. Fumaroles emitted large quantities of water vapor and SO_2. Many landslides had occurred in the walls of the main crater.

Information contacts: Guillermo Avila, Instituto Costarricense de Electricidad, Departmento de Geología, Apartado #10032, San José, Costa Rica.

Jorge Bárquero Hernández, Editor, Boletín de Vulcanología, Escuela de Ciencias Geográficas, Universidad Nacional, Heredia, Costa Rica.

Arenal Volcano, western Costa Rica (10.48°N, 84.72°W). A lava flow, the 34th since almost continuous extrusion of lava started in 1968, continued to descend the W flank. By mid-March, the flow had divided into five lobes. Geologists noted an increase in the chlorine content of gas emitted from the summit area.

Information contacts: Same as for Poás.

Earthquakes

Date	Time, GMT	Magnitude	Latitude	Longitude	Depth of Focus	Region
Mar. 4	2158	6.5 M_s	38.31° N	23.43° E	shallow	Greece
Mar. 8	1943	6.5 M_s	3.93° N	85.86° W	shallow	Off the N coast of South America
Mar. 10	1516	5.7 m_b	39.29° N	20.74° E	shallow	W Greece

The March 4 shock caused one heart-attack death and much damage in the S Volotia district, which was affected by the February 24–25 earthquakes. It was immediately followed by 1-m-high tsunami that covered the coastal area between Corinth and Loutraki at the end of the Gulf of Corinth. No damage or casualties were reported after the March 8 event. The March 10 earthquake in W Greece, near the Albanian border, killed two persons in rockfalls and damaged about 150 buildings in the Preveza area.

Fireballs

Belgium, December 8, 1980, 1838 GMT. Pierre Vingerhoets of the VVS Meteor Section reported that three persons in Alsemberg (Brabant) saw a fireball of magnitude −8 to −10. Its color was glistening white, its head shaped like a raindrop. From between alpha and beta Andromeda it travelled SW and vanished 15° above the horizon.

Information contact: Robert A. Mackenzie, Director, British Meteor Society, 26 Adrian Street, Dover, Kent, England CT17 9AT.

Great Britain, December 26, 1980, 0250 GMT. A fireball of brightness comparable to the gibbous moon was seen for 3–4 s by four observers. No further details are currently available.

Information contact: Same as for Belgium.

Central Italy, 5 January, 1818 GMT.
Observer: Andrea Bassanini
Location: Rome (41.9° N, 12.5° E)
Start: R.A. 12 h 30 min (± 10 min), declination +75° (± 4°)
End: R.A. 9 h 00 min (± 10 min), declination +63° (± 4°)
Duration: 0.5 s
Brightness: Magnitude −7.5 ± 1
Color: Orange-yellow
Train: Orange-yellow and very large
Information contact: Same as for Belgium.

Western Australia, January 2, 1550 GMT (2350 Western Australian Standard Time).
Observer: C. Willoughby
Location: Belmont, a suburb of Perth
Start: Alpha = 116°, delta = +28°
End: Alpha = 123°, delta = +41°
Radiant: Sporadic
Speed: Very slow
Duration of train: 9–10 s
Brightness: Magnitude zero to − 11; it lit up the surroundings.
Color: Red at front; flared to violet-blue
Information contact: Same as for Belgium.

New Publications

Coal Burning Issues

A. E. S. Green (Ed.), University Presses of Florida, Gainesville, x + 390 pp., 1980, $10.00.

Reviewed by Allen F. Agnew

The anticipated large increase in coal utilization in Florida recently triggered a multidisciplinary assessment by more than 30 faculty and staff at the University of Florida, under the auspices of the Interdisciplinary Center for Aeronomy and (other) Atmospheric Sciences (ICAAS). The ICAAS has conducted research on atmospheric pollution for the past decade, but this book addresses many more facets related to coal burning than that.

As is noted in the preface, the book was written 'with the hope of accelerating examination of a series of critical, long-term strategic and short-term tactical options' (p. ix). Its intended audience is not named, but it could include the broad academic community, governmental leaders and staff people, especially at the state level, and interested laymen.

This book, which examines the phenomena associated with the transition to coal use, is well worth reading. Like all such collections, the authors' styles and familiarity with the subject matter make it somewhat uneven reading—but not bad.

The Introduction and Summary is followed by 17 chapters, which discuss coal supply, extraction, and transportation; burning technology and synthetic fuels; atmospheric pollution and health effects; water resources; solid waste and trace elements; agriculture; technological innovations; federal laws and regulations; financing; and public policy choice. Some of the chapters seem out of sequence, and one or two are detailed case histories of projects done by ICAAS for Florida—suggesting that the audience is at the state level rather than the national.

A total of 33 authors, including 13 full professors and 13 research assistants and associates, wrote the 18 chapters. Although many of the chapters were written by authors whose works are cited herein, other chapters were not. It is understandable that most universities would not have on their staff specialists familiar with each of the coal burning issues; nevertheless, this reviewer would have preferred to see such specialists brought in, so that nuclear engineers would not have been saddled with the task of writing the chapter on coal availability and mining and the chapter on coal-burning technology.

Some chapters seem to come up short (for example, the one on quantitative public policy assessments by a physicist and a nuclear engineer). This reviewer expected a sociologically oriented treatment, rather than a detailed discussion of alternate methodologies for abating air pollution on which public policy decisions could be made.

Chapter 2, 'Coal Availability and Coal Mining,' is a brief noncritical discussion of coal characteristics, geographic distribution, domestic demand, mining and preparations, and mine safety and health.

Chapter 3, 'An Energetics Analysis of Coal Quality,' looks at coal quality and net energy yields by means of three types of models and concludes that 'most coal is of lower energy quality than oil or gas . . . [and that] the amount of useful work which can be derived from the world's coal reserve is actually somewhere between 45% and 74% of current estimates' (p. 67).

The chapter on coal transportation reminds us that coal (in 1975) was shipped by the following modes: rail (65%), water (11%), truck (12%), and other (1%), with 11% being used at mine-mouth plants. A 1978 study by the Congressional Research Service showed that the percentages projected by the Edison Electric Institute for the years 1985 and 2000 remain the same. Future expansion of the coal transportation network, the authors state, is clouded by federal regulatory policy, which varies from almost no control in some modes to a complete roadblock to expansion in others. If the system is to be expanded, the rail mode must carry the major burden of growth, but this, however, will result in major environmental and social problems.

Coal-burning technology, the subject of chapter 5, deals mainly with concentrated use (electric utilities and large industries) and dilute use (residential). The former provides for economies of scale and for removal of pollutants, whereas the latter use presents environmental problems in populated regions. The several established techniques, and a number of experimental ones, are briefly described and are assessed by the authors, who are nuclear engineers. In contrast to most other chapters, the bibliography for this one is skimpy.

Chapter 6, 'Synthetic Fuels for Coal,' is a solid discussion of coal conversion processes, including a comparison of existing processes and their economics, as well as a section on ongoing research in this very active area. A brief description is given of three major alternatives to coal as a source of synthetic fuels: petroleum residuals, oil shale, and oil from tar sands. 'Making fuels and related products from coal will soon be attractive for other than purely economic reasons . . . [because] the products . . . are essentially pollution free' (p. 129). A very thorough set of references is included.

Technological innovation is the topic of chapter 7, and it urges us to solve the technological complexities of integrated utility systems, the economic and bureaucratic regulatory constraints of cogeneration systems, the psychological matter of public acceptance of the electric automobile for commuting, air-pollution controls, problems of waste disposal, the economics of coal cleaning, the desirability of offshore coal-fired power plants, and the coal-plant siting debate between concentrated (energy parks) or dispersed schools of thought.

Chapter 8, 'The Water Resources,' includes summary presentations on water availability and contamination potential, energy development versus other water use, and water from coal. Regarding the latter, the authors point out that 'since most lignite is mined in dry regions where water is at a premium, recovery and use of the water in lignite [which can "range up to fifty percent by weight"], could provide a significant contribution to the water required in many coal processes' (p. 167).

Chapter 9, 'Atmospheric Pollution,' outlines both actual and potential impacts resulting from increased use of coal. 'Nationwide elevated SO_2 trends' would be created if strict emission controls are not enforced (p. 173). The author writes of the increased nitrogen and carbon oxides that would be added to the atmosphere and expresses concern over the water vapor emissions from coal-fired plants. [They] may facilitate other chemical reactions within the plume or cause visibility problems (p. 176). In writing about inorganic trace elements emitted from coal-fired units, the author starts from an erroneous base, writing that 'most trace elements found in coal appear in concentrations which approximate the earth's continental crustal material.' Actually, numerous studies have shown that trace elements seem to have been concentrated in coal because of biogenic processes. The author concludes, correctly, that the enriched trace-element concentration in coal-fired plants forms a subtle threat, both long term and short term, to the environment.

Chapter 10 continues this atmospheric theme by discussing air pollutant dispersion modeling. The author cites the three general types of models: Gaussian, transport, and stochastic. Surprising to this reviewer is the statement that the Gaussian models have very limited validity, with errors of several hundred percent being not uncommon, yet the Gaussian models are widely used and form the basis for the EPA-recommended 'off-the-shelf' models. The transport models are more rigorous and thus are mathematically more complex and usually require meteorological data that are not always available. However, the transport models also require knowledge of eddy diffusivities or 'K' values which (like the dispersion coefficient of the Gaussian models) also cannot be accurately predicted. Stochastic models, concludes the author, are both most rigorous and most adaptable, but the stochastic models are only in a developmental stage and require meteorological data that are not always available. The reader thus has to agree with the author in that there is a 'great need to develop reliable yet practical methods for quantitative prediction of the dispersion of air pollutants emitted in coal burning' (p. 201).

The third of these chapters on air pollution, 'Atmospheric Modifications,' is concerned with whether or not perturbations induced by coal-fired plants are significant depends on the magnitudes of combustion sources in comparison to natural sources of such items and the rapidity with which they are scavenged before being dispersed throughout the atmosphere. The authors note that acid rain is due to the release of both nitrogen oxide and sulfur dioxide that, in combination with rainwater, result in low pH and that one important method of monitoring aerosols and the deterioration of visibility on a global scale is by remote sensing from orbiting satellites. The authors present a brief summary of such monitoring with emphasis on the Nimbus-7 Atmospheric Laboratory.

Solid waste and trace element impacts are the subjects of chapter 12, and the discussion dwells heavily upon the 1978 monographs by S. Torrey, 'Trace Elements from Coal' (*Pollution Technology Review* No. 50) and 'Coal Ash Utilization: Fly Ash, Bottom Ash, and Slag' (*Pollution Technology Review* No. 48), which preceded the proposed hazardous waste regulations under the Resources Conservation and Recovery Act of 1976 and the environmental impact statement in the Powerplant and Industrial Fuel Use Act of 1978. The author summarizes the occurrence of trace elements in coal and fly ash (including radioactive daughter products of uranium and thorium) and gives a brief review of potential health effects. He suggests that models of environmental transport and of dose-to-risk be developed and discusses the importance of the Resource Conservation and Recovery Act and the Toxic Substances Control Act. This reviewer found the chapter to be one of the more interesting and significant ones in the book.

In Chapter 13, 'Agriculture,' the authors comment that the impact of coal residues on agricultural and forest environments depends on the distribution of such residues between solid waste (90%) and released emission products (10%). Atmospheric SO_2 and acid rain may have been well documented qualitatively but not so well quantitatively. Further, adverse trace-element impacts on agriculture and ecosystems will probably be of a much lower order of magnitude than impacts of sulfur oxides. On the other hand, potential benefit can be obtained from disposing of coal's solid-waste residues on agricultural and forest soils, provided that their compatibility with specific soils is determined ahead of application so that it will not be indiscriminate.

The health side of the coin is the subject of Chapter 14, whose authors do a good job of evaluating primary pollutants (SO_2 particulates, NO_2, CO, and trace elements) and secondary ones (ozone and aerosols). Both epidemiological and controlled laboratory studies, in which both animals and humans were exposed to various pollutants, are discussed, and the authors caution the reader that epidemiological studies (which allow one to evaluate the effects of air pollution on large numbers of people over a lifetime) are, unfortunately, the most difficult to conduct. Despite these hurdles, there is some evidence that sulfur dioxide, sulfates, and particulates have some detrimental effects on the health of children and adults. This reviewer was distressed, however, with the authors' extrapolations (obscurely based) in a few places, such as their statement that 'silicosis [has been] found in coal miners' as a consequence of such exposure (p. 283); 'such' may refer to one of several previous statements in that paragraph.

The authors, however, did caution us not to overestimate the carbon monoxide problem with coal-fired plants, noting that only 2% of the CO emissions in the United States are due to combustion of coal and oil, the rest being the result mostly of automobile exhaust. Furthermore, the authors state that present CO levels in our environment are low and pose little threat to our health, except in high-density traffic lanes and near improperly vented stoves, and that the CO_2 level in the environment today (440 ppm) has no known health effect (p 287).

As is mentioned in the general discussion above, Chapter 15, Quantitative Public Policy Assessment, was a disappointment to this reviewer. The authors present a case study by ICAAS which 'attempted to carry out an integrated interdisciplinary assessment of air pollution abatement alternatives in the Tampa area of Florida.' (p. 29). The authors attempt to move from a proposed Air Quality Index through a broad socio-technical research program to the establishment of a quantitative scale for air quality. They use two types of public policy decision methodologies (on sulfur oxide pollution): (1) Disaggregate Benefit/Cost Analysis, and (2) Quantitative Assessment of the Level of Risk. They merely describe how they went about the study in a very technical presentation, and this reviewer was disappointed in not seeing some conclusions or recommendations. Instead, the final section of the chapter is entitled 'The International Context'; it broadens the context, but adds little.

Capability for financing the conversion to coal by the utility industry is the subject of Chapter 16. The authors bemoan the weak financial position caused by a combination of economic and political factors of the average utility company. Many companies simply cannot meet the capital requirements of such coal expansion. The authors recommend that utility commisions realistically analyze the situation and then allow the utility companies to charge prices which would cover the cost of capital invested.

In chapter 17, 'Coal and the States: A Public Choice Perspective,' the author, who is a political scientist, stresses his view that the implementation of a national coal policy will depend heavily upon the states, owing to traditional state powers affecting coal use and because of the state's discretionary authority in implementing federal coal policy. In formulating state coal policy, state governments will face competing and conflicting policy objectives and priorities, just as the Congress and the Administration do at the national level. The author calls for federal assistance in resolving state policy issues and urges the federal government to hold the massive new coal utilization to only a few decades; to create a target growth rate for the United States; to emphasize energy conservation by dampening demand; and to encourage greater public involvement in coal-policy formulation among the western states, where the environmental risks of coal development are especially acute. In fact, the author recommends that the federal government provide statutory authorization to federal and state agencies having surface-mining regulatory authority, so that they can 'allocate funds to public-interest groups for purposes of educating the state publics on such programs,' (p. 357).

The final chapter, 'Federal Regulatory and Legal Aspects,' deals both with enacted laws and with laws under consideration by the Congress. Federal laws and regulations both encourage and constrain coal use. Good examples are provided by the regulation of such operations as mining, transportation, and power generation. Whereas the authors write about the strengths and weaknesses of laws on the books, they can only hazard a guess as to how far the Congress might go in modifying bills being considered. Because the authors do present their views of the potential directions of some of the alternatives before Congress, this chapter provides an air of currency to a subject that could easily have become outdated. The authors note that hazardous waste regulations under the solid waste disposal law (Resource Conservation and Recovery Act of 1976) 'show a greater inclination to encourage coal utilization at the expense of threats to environmental safety than do air and water regulations. . . perhaps . . . to prevent the arousal of public opposition to coal conversion at a time when other alternative energy sources are not available' (p 373).

In summary, any comprehensive examination of the subject of increased coal use must give careful scrutiny not only to the individual laws but, even more importantly, to *how their implementation helps in support of or in conflict* with the expressed goal of increased coal use. Further, this reviewer would add, one must examine and become aware of how the regulations promulgated as extensions of those acts compound the problem.

Allen F. Agnew is a geologist and lives in Reston, Virginia.

Naissance d'un Ocean

J. Francheteau, D. Needham, T. Juteau, and C. Rangin, Centre Oceanologique De Bretagne, Brest, France, 84 pp., 1980, $37.00.

Reviewed by William S. F. Kidd

This paperbound, oversize but slender book is primarily a printed photographic record of the geological features recorded from the submersible *Cyana* during the CYAMEX expedition to the axis of the East Pacific Rise near 21°N. Accompanying the color pictures, which occupy about half the total space in the book, is the text with the French and English versions printed in two adjacent columns. This is not a primary scientific document, although it is a well-written and accurate summary of the surface geology. No references are given in the text, but two short lists are given at the back: one of general plate tectonic references and another of published results from previous deep submersible investigations on other segments of the oceanic spreading ridges. The approach most closely compares with an extended *Scientific American* article, with the major emphasis on the photographs.

The text has some introductory matter, including a page on the CYAMEX project, another on the history of discovery of the East Pacific Rise, two more on the features and operation of the submersible, and seven pages on the oceanic spreading ridge system, together with some pictures and several familiar-looking diagrams and maps. The main part of the text, which includes most of the pictures, is divided into three sections. These are on the creation of new ocean floor and the various volcanic features constructed there, on its early evolution away from the zone of active eruption, including fissuring, faulting, and sedimentation, and a shorter section on hydrothermal vents, the metalliferous deposits associated with them, and the fauna seen at these vents and in the area as a whole. The English text, presumed to be a translation, follows the French with remarkable accuracy and yet is mercifully unstilted. Some very minor descriptive portions of the text have been omitted from the English in a few places and from the French in some other cases. In general, the picture captions have been less faithfully matched, and some of the more enthusiastic French ones did not survive the severe English caption writer. A picture of a mud cloud about to envelop the submersible is entitled in French 'Triomphe du sédiment,' while the English only mutters prosaically about the sediment being fine-grained and easily stirred up.

The book is nicely printed, and it is true, as the text points out, that the pictures are remarkable and of good quality considering the constraints that cannot be avoided in obtaining color pictures on the deep-sea floor. The most visible of these constraints is the inevitable coarse grain of high-speed color film. Most of the pictures have been printed at half-page size, and in these the grain is not obtrusive, but a few at full-page size are beyond the limit of reasonable enlargement and would have been better printed at the smaller size. These include most of the few pictures included in this book that were taken from the submersible *Alvin* on a subsequent leg of the RITA project, giving a misleading impression of poorer photographic quality from this submersible. As a group, the pictures do not have the very blue tones characteristic of pictures from many submersible expeditions. I presume that this is due to subsequent filtration; it cannot be said that the colors in these or any other deep-sea photos necessarily resemble closely the colors the objects would possess in sunlight.

It is difficult to discern the audience that this document was aimed at. While it is certainly very nice to have so many pictures reproduced, and in color, the essential information from this program is or will shortly be published in reviewed journals. This book suffers from the usual major defect of most recent European publications, its high price. At a much lower price it might have found a niche, like a *Scientific American* collection of articles, in university courses in marine geology or vulcanology. As it is, I think that this is a book for large or specialized libraries. Only the most avid collector of pictures of small-scale volcanic landforms, and those directly involved with detailed research on the oceanic spreading ridges will probably want to sink $37.00 into purchasing this 84 page book. Price aside, much credit must be given to CNEXO and the authors for making these pictures available. It is to be hoped that a similar compilation can be made from U.S. submersible expeditions since Famous.

William S. F. Kidd is with the Geological Sciences department, State University of New York at Albany, Albany, New York.

Proceedings for Rock Mechanics Congress

The U.S. National Committee for Rock Mechanics has published volume III of the *Proceedings of the Third Congress, ISRM*, and is trying to find current addresses for those people who ordered copies but have not received them.

If you attended the congress, or if you placed orders for the proceedings and have not received your copy, please contact the U.S. National Committee for Rock Mechanics, 2101 Constitution Avenue, N.W., Washington, D.C. 20418, Attn: Barbara S. Adams.

Drilling Errata Published

The Deep Sea Drilling Project has completed errata for volumes 1 through 44 of the *Initial Reports of the Deep Sea Drilling Project*. Institutions in the United States and IPOD countries that routinely received copies of these volumes will automatically receive a complete set of errata. Complimentary copies of the errata are available upon request to all other volume owners. Please specify if you want errata listings for specific volumes or for the entire set. Send your request to Science Services, Deep Sea Drilling Project, A-031, Scripps Institution of Oceanography, University of California at San Diego, La Jolla, CA 92093.

New Listings

Items listed in New Publications can be ordered directly from the publisher; they are not available through AGU.

Climate Change and Society: Consequences of Increasing Atmospheric Carbon Dioxide, W. W. Kellogg, R. Schware, Westview Press, Boulder, Colorado, xiii + 178 pp., 1981, $15.00 (hardcover), $8.00 (paperback).

Dynamics of the Upper Atmosphere, S. Kato, D. Reidel, Hingham, Mass., xiii + 233 pp., 1980, $29.95.

Environmental Geology, D. R. Coates, John Wiley, New York, iv + 701 pp., 1981.

Hydrological Data-Norden, Representative Basins, Lappträsket, Sweden, Data 1971–1974, M. Persson, A. Simeonidis (Eds.), Swedish National Committee for the International Hydrological Programme, Stockholm, Sweden, 84 pp., 1979. (Available from Swedish National Committee for the IHP, Stockholm, Sweden.)

Interactions of Energy and Climate, W. Bach, J. Pankrath, J. Williams (Eds.), D. Reidel, Hingham, Mass., xxxvii + 568 pp., 1980, $58.00 (cloth), $26.50 (paperback).

The Last Great Ice Sheets, G. H. Denton, T. J. Hughes (Eds.), John Wiley, New York, xviii + 484 pp., 1981, $95.00.

Research Digest 1980 ICW, Tech. Bull. 117, E. W. Schierbeek (Ed.), Institute for Land and Water Management Research, Wageningen, Netherlands, vi + 229 pp., 1980.

The United States Energy Atlas, D. J. Cuff and W. J. Young, Free Press, New York, viii + 416 pp. 1980, $75.00.

Viking Orbiter View of Mars, C. R. Spitzer (Ed.), National Aeronautics and Space Administration, Washington, DC, vii + 182 pp., 1980.

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Applicants should send curriculum vitae and a list of three references to:

Robert A. Phinney
Department of Geological and Geophysical Sciences
Princeton University
Princeton, NJ 08544

Or enquire: 609-452-4118
Date of appointment and salary are negotiable.

Princeton University is an equal opportunity employer.

Physical Oceanography. A research and teaching position for a visiting scientist is available for the 1981–82 academic year. The position is state supported with a salary range of $19,000 to $29,000 for nine months at a rank from assistant to full professor, depending on the applicant's previous experience. Applicants should have demonstrated experimental research ability in current dynamics, waves, turbulence or ocean remote sensing, and should be willing to teach at least one course. Interest in interacting with existing research programs in turbulence, optical oceanography, or coastal processes is encouraged.

Send curriculum vitae, the names and phone numbers of three references to: Chairman, Department of Marine Science, University of South Florida, 830 First Street South, St. Petersburg, Florida, 33701. Application will be accepted through June 30, 1981.

Seismology, Sedimentology and Tectonics/Geochronology. The Geosciences Program of The University of Texas at Dallas invites applications for three anticipated tenure track openings in the general areas of seismology, clastic sedimentology and tectonics/geochronology beginning academic year 1981–82. At least one of these positions will be filled at the senior level with rank and salary commensurate with qualifications.

The positions require a Ph.D. and a strong commitment to excellence in research and teaching. Teaching duties will involve both graduate and undergraduate courses, some participation in field courses and supervision of M.S. and Ph.D. students. Candidates with the following research interests are preferred:

Seismology—expertise in solid earth seismology with an interest in applying theoretical modeling or signal processing techniques to earthquake or other seismic problems. Academic Search No. 236

Clastic sedimentology—expertise in depositional systems and/or diagenesis. Academic Search No. 237

Tectonics/geochronology—Expertise in regional geology/tectonics with an interest in isotope geochemistry, geochronology, and petrology. Academic Search No. 238

Applicants should send a letter outlining specific research interest, a resume (indication of sex and ethnicity for statistical purposes is requested but not required) and names of three references, with the appropriate Academic Search Number, to:
Academic Search No. ___
The University of Texas at Dallas
P.O. Box 688
Richardson, Texas 75080

Applications should be received by July 31, 1981.

The University of Texas at Dallas is an affirmative action/equal opportunity employer.

Faculty Position/University of Alaska, Fairbanks. Applications are invited for a tenure track faculty position in economic geology in the Geology Geophysics Program to teach undergraduate and graduate courses in ore deposits, mineralogy, and exploration geology.

Applications should have demonstrated practical experience in mineral exploration, regional and detailed geologic mapping as well as a commitment to research in the genesis of ore deposits. The candidate will be expected to pursue a vigorous graduate teaching and research program in economic geology with students primarily oriented toward careers in the mineral industry.

Preference will be given to individuals with experience in arctic or subarctic minerals research and a record of close collaboration with the mineral industry. Academic rank and salary commensurate with experience. Ph.D. required.

Send resume and three letters of reference Director, Division of Geosciences, University of Alaska, Fairbanks, Alaska 99701. Applications will be accepted until June 30, 1981, or until filled.

The University of Alaska is an equal opportunity/affirmative action employer.

Petrology/Geochemistry, University of New Brunswick. The Department of Geology has a tenure track position available from 1 July, 1981, at assistant professor or higher level. The successful applicant will be expected to teach both undergraduates and graduates as well as carrying out research and supervising graduate students. This position is in addition to one currently advertised for a rock mechanic or geochemist.

The applicant should have a background in petrochemistry and petrology and should be prepared to teach in some aspects of petrology and geochemistry. The successful applicant will be responsible for supervision of analytical facilities including an X.R.F.

Applicants should have a Ph.D. and preferably, post doctoral experience. Applications including a curriculum vitae and names of three referees should be sent to P. F. Williams, Chairman, Department of Geology, University of New Brunswick, Fredericton, N.B. E3B 5A3.

Hydrogeologist. Applications invited for a permanent faculty position. The position requires a Ph.D., teaching at graduate and undergraduate levels, supervision of research, and research in area of specialty. Interaction with faculty in surface water hydrology, stable-isotope geochemistry, geophysics, and sedimentary geochemistry is expected.

Candidates should send resume, statement of research interest, and addresses of three references to L. D. McGinnis, Chairman, Department of Geology, Northern Illinois University, DeKalb, IL 60115.

An equal opportunity/affirmative action employer.

Faculty Position in Oceanography/Geology: University of Northern Colorado. The Department of Earth Sciences invites applications for a full-time, tenure track faculty position in oceanography, starting September 1981. We are seeking a person with a broad background in oceanography and one or more of the related earth science fields such as marine geology and/or sedimentology. Major responsibility will be teaching beginning and advanced courses in oceanography, courses in the related field, and general education courses. A modest amount of research is possible and is encouraged. Applicants should possess the Ph.D. degree or be in the final stages of completion of that degree. Starting rank and salary will depend on experience and other qualifications of the candidate selected.

Applicants should submit a resume and at least three letters of recommendation to Dr. L. Glen Cobb, Chairman, Department of Earth Sciences, University of Northern Colorado, Greeley, CO 80639.

The deadline for application is May 10.

EXPERIMENTAL ATMOSPHERIC CHEMIST

To conduct independent research likely to include marine measurements, tropospheric and stratospheric sampling, global chemical cycles and related scientific areas and management of research group. Requires majority of the following: Ph.D in chemistry, physics, oceanography, atmospheric science or a closely related discipline or equivalent plus extensive experience with laboratory and/or field measurements relevant to atmospheric chemistry; outstanding skill in experimental techniques for gas measurements; recognized publication record, demonstrated skill at supervising experimental scientists in research endeavors and interacting productively with colleagues in theoretical studies. Salary range: $34,446-$56,796. Candidates may apply by submitting a curriculum vitae and list of publications. Qualification at level III or senior scientist will be based on the degree to which the applicant satisfies the requirements. The Ph.D. scientist III level will be a five year term appointment. For more information or to apply, contact Margarota Domecki, NATIONAL CENTER FOR ATMOSHPHERIC RESEARCH, P.O. Box 3000, Boulder, Colorado 80307, (303) 494-5151, ext. 581

NCAR

NCAR is an Equal Opportunity/Affirmative Action Employer

ERT, the nation's leading environmental consulting firm, has immediate openings in its Energy Development and Engineering Center for Environmental Engineers.

PRINCIPAL WATER QUALITY ENGINEER

You will provide technical and managerial leadership to the Water Quality Engineering Division. Prepare water quality assessments for NPDES permit applications, and manage permitting projects. This position requires familiarity with water pollution regulations and their impact on the specifications of waste water treatment systems, and in-depth knowledge of stream modeling. Minimum seven years experience in NPDES permitting and water quality assessment; MS in chemical/civil engineering.

STAFF WATER QUALITY ENGINEER

You will assist Senior Water Quality Engineers and perform technical assessments/stream modeling, and prepare engineering reports at the direction of a senior engineer. Minimum BS in chemical/civil engineering required; training and experience with waste water treatment systems and stream modeling desired.

Please send resume and salary history to Ronald J. Haddad, Employment Manager, Environmental Research & Technology, Inc., 696 Virginia Road, Concord, MA 01742.

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ENVIRONMENTAL RESEARCH & TECHNOLOGY, INC.
ATLANTA · CHICAGO · CONCORD, MA · FORT COLLINS, CO
HOUSTON · LOS ANGELES · PITTSBURGH · WASHINGTON, DC

An Equal Opportunity Employer M/F

Atmospheric Scientist/Radiation Physicist. Current Applied Research and Systems activities have created immediate openings in the following areas:

1. Spectroscopy, Radiative Transfer and Atmospheric Sciences (1 Position). Requires to work on the general circulation modeling of stratosphere.
2. Atmospheric Fluid Dynamics (1 Position). Requires to develop global atmospheric dynamics problem in the thermosphere.

These positions are in support of science and application tasks of NASA/Goddard Space Flight Center, Greenbelt, Maryland and require one to work onsite.

An extensive background in the numerical simulation of physical problems by use of mini and large computers is required. Candidates must have M.S. or Ph.D. in atmospheric sciences or physical sciences. Both of these positions are renewable up to two years.

Salary range is $21,000 to $35,000 per annum, depending on qualifications. Good Benefits. Qualified applicants should send three references, salary history and requirements to:
Dr. S. P. S. Anand
Applied Research and Systems
8401 Corporate Drive
Suite 650
Landover, MD 20785
Telephone (301) 459-8442

Kutztown State College. Applications are invited for a temporary one-year full time appointment in geology commencing September 1981. The successful candidate will be expected to teach an advanced undergraduate course in environmental geology and to participate in teaching introductory geology. Demonstrated teaching experience in the above areas is required. The Ph.D. degree is preferred. Applicants should forward a resume, an unofficial transcript, and arrange for early submission of three letters of recommendation to: John Scott, Phys. Sci. Dept., Kutztown State College, Kutztown, PA 19530.

Kutztown State College is an equal opportunity/affirmative action employer.

Sedimentologist-Sedimentary Petrographer/Ohio State University. The department of Geology and Mineralogy invites applications for a tenure track faculty position in sedimentology-sedimentary petrography. The appointment is available from August 1981.

Salary and rank competitive and commensurate with experience.

Applicants should send resumes and names of at least three referees or address inquiries for further information to Peter-N. Webb, Dept. of Geology and Mineralogy, The Ohio State University, 125 South Oval Mall, Columbus, Ohio 43210. Closing date is July 1, 1981.

The Ohio State University is an equal opportunity/affirmative action employer.

Dean, College of Geosciences. The University of Oklahoma is seeking a dean for its newly formed College of Geosciences, a college which is comprised of three existing academic departments: Geology and Geophysics, Meteorology, and Geography. In 1981–82 the total faculty will reach approximately forty full-time persons. Presently the student majors represent about 500 undergraduate and 220 graduate students. The College is expected to grow both in faculty and student body over the next several years. There is a firm institutional commitment to the continued development of academic quality in undergraduate and graduate education and research in the earth sciences, already an area of traditional strength at the University of Oklahoma.

Candidates for the deanship should possess a doctorate in an earth science discipline, and should have significant experience in an administrative or academic role involving instructional and/or research activities relevant to the earth sciences. While an understanding of and appreciation for all of the earth sciences is essential, because of the unique traditions of the University of Oklahoma and its relationship to the state and region, there will be a significant focus on energy activities and research.

Among the dean's responsibilities will be: (1) to provide leadership, internally and externally, in energy matters and, particularly, in working with the petroleum and gas industry throughout the Southwest; (2) to assist in the planning and development of a $30 million Energy Center which will house the College of Geosciences and other energy-related disciplines and services; and (3) to provide administrative leadership for instruction and research in such areas as atmosphere, weather and climatology; physical, economic and cultural geography; and the basic areas of geology, geophysics, and geochemistry.

The dean should be able to assume this position in September, 1981, or as soon as possible thereafter, no later than January, 1982. Closing date for applications is June 1, 1981. Please send nominations, applications, and arrange for at least three letters of reference,
EO/AE. Apply: Professor Neil E. Salisbury, Chair, Geosciences Dean Search Committee, Department of Geography, University of Oklahoma, Norman, Oklahoma 73019.

University of Leeds/Isotope Geochemist. Applications are invited for a temporary appointment for a fixed term of up to two years as postdoctoral research fellow in the Department of Earth Sciences, from a date to be arranged, to work on a project in isotope geochemistry and geochronology, funded by the Natural Environment Research Council, UK.

Preferred special interests and experience are expected in radiogenic isotope geochemistry applied to petrogenetic studies and/or mantle evolution. Current isotopic research includes investigations into specific intra-plate and island-arc volcanic provinces, mantle nodules, Precambrian geochronology, thermal evolution of metamorphic belts, and sea-water/sediment interactions.

Salary within the range £6070–£10,160 on the IA Scale for Research and Analogous Staff (£6070–£10,575) according to age, qualifications and experience.

Informal enquiries may be made to Professor J C Briden. Further particulars and application forms (if desired) may be obtained from the Registrar, The University, Leeds LS2 9JT, U.K., quoting reference number 49/16/HG. Closing date for applications 31 May 1981.

Faculty Position/Atmospheric Sciences. The University of Arizona has an opening for a tenure track faculty position in the Department of Atmospheric Sciences. The appointment can be made up to and including the rank of associate professor. Some preference will be given to candidates with specialization in one or more of the following areas: synoptic meteorology, satellite meteorology, boundary layer meteorology, air pollution, and air-sea interactions. The applicant must have an earned doctor's degree in the atmospheric sciences or a related discipline. Applications will be accepted until August 1, 1981. Appointment can be effective as early as January 16, 1982. The candidate must have a dedication to undergraduate and graduate teaching and is expected to develop a high quality research program. Interested individuals should submit a complete curriculum vitae, a list of publications, a statement of teaching and research interests, and three letters of recommendation (sent directly by the writers) to Louis J. Battan, Head, Department of Atmospheric Sciences, University of Arizona, Tucson, Arizona 85721. Phone (602) 626-1211.

The University of Arizona is an equal opportunity/affirmative action employer.

Postdoctoral Position. Atmospheric geochemistry/air pollution project is seeking applicant with interest in environmental or atmospheric geochemistry by summer or fall 1981. Project involves study of source and ambient airborne particles with SEM, TEM, and INAA. Background in analytical or atmospheric geochemistry desirable; knowledge of meteorology and/or statistics would be helpful. Send resume, statement of research interests, names of three references to Dr. P. R. Buseck, Department of Geology, Arizona State University, Tempe, AZ 85281.

ASU is an EO/AA employer.

Research Position/University of California, San Diego. Research position to study the horizontal and vertical circulation of the Norwegian-Greenland Sea. Applicants should have a background in the physical oceanography of high latitudes, experience in work at sea, and a Ph.D. or equivalent. Position support by extramural funding. Salary: $21600 to $22500 per year commensurate with experience. Submit resume including names of three references before June 10, 1981 to: Director, Marine Life Research Group, A-030, Scripps Institution of Oceanography, La Jolla, CA 92093.

The University of California is an equal opportunity/affirmative action employer.

Postdoctoral Position/UCLA. Postdoctoral position in experimental geochemistry/petrology available immediately for research on lower-crust/upper-mantle problems. Successful applicant will have a strong background in thermodynamics and petrology. Send application to Art Boettcher, Institute of Geophysics & Planetary Physics, University of California, Los Angeles, California 90024.

UCLA is an equal opportunity/affirmative action employer.

Irrigation Engineer. Assistant professor, tenured track position in the Departments of Land, Air and Water Resources and Agricultural Engineering, 40% teaching and 60% research. Ph.D. in engineering or related field with strong background in irrigation and hydrodynamics. Applicants should have a demonstrated interest in agriculture with competence in the design and performance of on-farm irrigation systems.

Teaching and responsibilities include undergraduate level courses in Water Application Systems and Sprinkler and Drip Irrigation System Design and a graduate level course in Hydraulics of Surface Irrigation. Research in innovative and water-conserving application methods, including considerations of energy conservation and automation would be expected.

Applicants should submit resume, transcripts, copies of publications and manuscripts, and names and addresses of at least three references to: Prof. V. H. Scott, Recruitment Committee Chairperson, 113 Veihmeyer Hall, Dept. of Land, Air and Water Resources, University of California, Davis, California 95616, prior to July 15, 1981. This position is to be filled during the 1981–82 academic year.

The University of California is an equal opportunity affirmative action employer and invites applications from all qualified individuals.

Stanford University. Applications are invited for a faculty position in geochemistry in the Department of Geology. The level of appointment will depend upon the qualifications of the individual, but our search will focus on younger scholars at the assistant and associate professor level. We seek an individual fully committed to a vigorous research and teaching career and one who is enthusiastic about teaching at both the graduate and undergraduate levels. The field of research can be in any area of inorganic geochemistry—we are most concerned that the candidate display evidence of exceptional creativity and scholarly drive. We anticipate that the new faculty member will join us during the 1981–82 academic year. Interested individuals should send letters of application including vita, statement of research and teaching interests, and names of three references to:

George Thompson, Chairman
Department of Geology
School of Earth Sciences
Stanford University
Stanford, CA 94305

Stanford is an equal opportunity affirmative action employer.

Research Associate. The Coal Extraction and Utilization Research Center at Southern Illinois University, Carbondale, has a research associate position available immediately for a highly qualified person to coordinate the preparation of the mining reclamation mining handbook.

The candidate is expected to have a Ph.D. or M.S. (with equivalent experience) in natural resource sciences with research experience in the environmental monitoring aspects of the coal mining industry. Knowledge of the environmental requirements of permitting, mining, and reclamation as required by the Surface Mining Control and Reclamation Act of 1977 and skills in writing and editing manuscripts, are preferred.

The successful candidate is expected:

1) to assemble environmental monitoring requirements and methodologies for the various mining regions of the country noting variation due different mining methods employed by large and small mines.
2) to develop environmental monitoring bibliography for surface coal mining;
3) to coordinate the effort of a writing team producing the draft manuscript;
4) to direct an editing team producing the camera ready manuscript for final publication.

The position is for 18 months with a salary range of $1,600 to $1,800 per month. Deadline for applications is May 15, 1981. Send resume, transcripts, and names of at least three references to

James B. Gulliford
Assistant Director
Coal Extraction & Utilization
Research Center
Southern Illinois University
Carbondale, Illinois 62901.

Southern Illinois University at Carbondale is an equal opportunity / affirmative action employer.

conoco

Electrical Methods Research Geophysicist

The Exploration Research Division of Conoco Inc. is interested in hiring a Ph.D. level scientist who is competent in all aspects of electrical methods. The job will emphasize the development of electrical methods in a research environment to obtain operational systems for solving real exploration problems. The applicant should be capable of handling field equipment and be interested in the applications, acquisition, and interpretation as well as the theory of electrical methods. Applicants should submit a vita, official transcripts of all college level work, and four references with phone numbers to:

John Oehler
Technical Assistant to the Manager
Exploration Research Division
Conoco Inc.
Ponca City, Oklahoma 74601

An Equal Opportunity Employer

SERVICES

Scripps Remote Sensing Tutorials.

1A. *Overview of the Remote Sensing Facility*—This one-day seminar describes the data bases, sources and processing capabilities available at Scripps Institution of Oceanography, Remote Sensing Facility. A morning lecture will introduce past, current and future space platforms available for observation of the Oceans. A brief discussion of where and how to access this information will conclude the first part of the class.

The afternoon will include a demonstration of processing and displaying imagery obtained from TIROS-N, NOAA-6 and NIMBUS-7.

Classes will be held at the Helen Raitt Room SIO Library on Monday, April 20, 1981 and Monday, July 27, 1981, at 8:30 am. A nonrefundable fee of $50.00 must be submitted with the application. Enrollment limit—12.

2A. *Users Introduction to the Scripps Remote Sensing Facility*—This four-day workshop is intended exclusively for individuals who will be using the facility at Scripps. Two morning lectures will describe in detail the hardware, software and personnel resources available to oceanographers. Existing data bases, their characteristics, location, mode and cost of access will be covered. Basics of image processing will be introduced along with in-depth look at the Interactive Digital Image Manipulation System used at the SRSF.

The two lectures will be followed by afternoon lab sessions which consist of hands-on exercises to familiarize users with the hardware/software at the facility. The third morning will be devoted to train users in realtime spacecraft tracking and data recording and acquisition.

The remainder of the 3rd day and the entire 4th day will be used to work with users on a one-to-one basis. Attendees are encouraged to bring their own digital tapes with data of interest to them, which can be used during this last portion of the workshop.

Classes will be held in the Helen Raitt Room SIO Library starting on Tuesday, April 21, 1981 and Tuesday, July 27, 1981 at 8:30 am. A fee of $335.00 must be submitted with each application. Enrollment limit—6.

For more information regarding applications, fees, etc., please contact University of California at San Diego, SRSF/SIO, Mail Code A-030, La Jolla, California 92093 or (714) 452-2292.

SUPPLIES

Rock Hammer with pick head and leather holster for $16.00. This is $6.00 below list price. Write for free catalog "Geologic Field Supplies and Prospecting Equipment". Western Heritage, 101 S. Washington St., Hinsdale, IL 60521. Telephone (312) 964-5228.

AGU

Supporting Members—Individual

AGU GIFT

Individual members who contribute $80 or more per year over and above their dues are designated as individual supporting members. Contributions may be specially designated to support any Union program or project, added to the endowment fund, or given without restriction. In addition, the Committee on Financial Resources has directed that members contributing $80 or more to AGU-GIFT be recognized as supporting members. The following are so designated:

William C. Ackermann, L. Thomas Aldrich, Richard J. Anderle, Allan V. Cox, Anton M. Dainty, Earl G. Droessler, Richard Groeber, Charles Helsley, J. Brackett Hersey, John K. Hall, John K. Howard, Arnold I. Johnson, Carl Kisslinger, Serge A. Korff, Helmut E. Landsberg, Paolo Lanzano, Thomas F. Malone, Elwood Maple, Murli H. Manghnani, Jerome Namias, Barry E. Parsons, David F. Paskausky, Louis Q. Quam, Phillip B. Russell, James C. Savage, Erick O. Schonstedt, Waldo E. Smith, Kendall L. Svendsen, Charles V. Theis, James A. Van Allen, John W. Vanderwilt, Charles A. Whitten, Loren P. Wicks.

AGU SCHOLARSHIP ASSISTANCE FOR THE ACADEMIC YEAR 1980–1981

The June Bacon-Bercey Scholarship in Atmospheric Sciences for Women

Scholarship assistance in the amount of $400 will again be made available to a woman who intends to make a career in the atmospheric sciences. The award, which is provided through a gift from June Bacon-Bercy, a noted practicing meteorologist, will be made on the basis of academic achievement and promise. To be eligible for this scholarship, a candidate must be one of the following at the time of application:

- a first-year graduate student in a program leading to an advanced degree in the atmospheric sciences;
- an undergraduate in a bachelor's program leading to a degree in the atmospheric sciences, who has been accepted for graduate study in the field; or
- a student at a 2-year institution offering at least 6 semester hours of atmospheric sciences, who has been accepted for a bachelor's degree program in the atmospheric sciences and who has completed all of the courses in atmospheric science offered at the 2-year institution.

Application forms are available from the American Geophysical Union, Member Programs Division, 2000 Florida Avenue, N.W., Washington, D. C. 20009 (202/462-6903). Selection of the awardee will be made by the AGU Subcommittee on Women in Geophysics, in consultation with the AGU Meteorology Section.

DEADLINE FOR RECEIPT OF APPLICATIONS IS MAY 15, 1981

Meetings

Workshop on Thermal Measurements and Geothermal Exploration

A workshop for invited participants from government, industry, and academia was held at the Fort Burgwin Research Center of Southern Methodist University at Taos, New Mexico, from April 29 to May 2, 1979. Forty-five participants and five government observers attended the workshop, which was organized by David D. Blackwell of the Department of Geological Sciences at SMU and funded by the U.S. Geological Survey Extramural Geothermal Research Program. The purpose of the workshop was to acquaint the government participants with the applications of industry and to acquaint the industry participants with the techniques and expertise available in government and academia. Techniques that involved the measurement of the earth's heat flow, both convective and conductive, and the use of these measurements in exploration for geothermal systems were included in the scope of the workshop.

Participants gave presentations on and discussed heat flow and geothermal gradient techniques in conventional depth (40–150 m) drill holes, including cost effectiveness and significance of these measurements in exploration programs; drilling problems and gradient disturbances, such as water flow and topography; application of very shallow (1–3 m) temperature measurements in the inference of deeper thermal data and limits of reliable anomaly detection (about 400 mWm^{-2}, or 10 × 10^{-6} cal/cm^2-s); deep temperature, heat flow, and hydrology studies in 400–1000-m drill holes, especially the relation between shallow and deeper conditions; deep drilling (1000–3000 m) for location of commercial temperature systems (greater than 200°C for electrical power generation) and determination of reservoir structure; geochemical studies in geothermal systems for prediction of temperature; and interpretation of heat flow measurements and geophysical modeling techniques.

Regional and local case studies were presented by participants, including heat flow studies in the southeastern U.S., the Midwest, Wyoming and the Cascade Range; and geothermal systems in the Basin-and-Range province in Nevada and Utah.

The objective of the workshop was to promote interaction of the people involved in research and in application of techniques. Significant points raised were the need for a thermal methods infrastructure to service the industry involved in geothermal exploration; research in the development of techniques, equipment, and interpretive models specifically for geothermal studies; and the need for a regional data base of geothermal measurements to be used in locating and evaluating potential areas for hydrothermal power production, lower-temperature applications, and utilization of dry hot rock geothermal energy. Development of an understanding of conductive and convective heat transfer in the earth's crust and its implication to geothermal energy utilization is a major goal of research applied to geothermal exploration.

The workshop ended with a field trip to the Union Oil Baca Geothermal Project, in the nearby Valles caldera, and to the field site of the LASL Dry Hot Rock Project at Fenton Hill, on the margin of the Valles caldera, to illustrate to the participants the current and future potential of geothermal energy.

This meeting report was prepared and submitted by David D. Blackwell.

Chapman Conference on Spatial Variability in Hydrologic Modeling

July 21–23, 1981
Colorado State University, Fort Collins

Purpose: The conference will provide a forum where surface and groundwater hydrologists, soil scientists, and applied statisticians can discuss progress and research approaches in dealing with spatial variability of catchment surface and subsurface properties in a distributed modeling context.

Call for Papers: Published in December 16, 1980, Eos. Includes program topics planned. Abstract deadline: May 15, 1981.

Convenors: D. A. Woolhiser and H-J. Morel-Seytoux.

Student Travel: Some travel money will be available to students. To apply, write to AGU, giving your educational background and your advisor's name. Briefly explain the reasons you wish to attend.

For further information, call or write Member Programs Division, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009 (telephone: 202/462-6903).

Estuarine Comparisons

The Estuarine Research Federation will sponsor the Sixth Biennial International Estuarine Research Conference from November 1–5, in Gleneden Beach, Oregon. The theme of the conference is 'Estuarine Comparisons.'

The preliminary program includes invited sessions on larval retention in estuaries, estuarine sediment dynamics and sedimentation control, ecodynamic comparisons between estuaries, the origin and development of the Yangtze Estuary, comparisons among anadromous fish in estuaries, and dynamics beneath the marsh soil surface. Field trips to nearby marine laboratories will be scheduled.

For additional information and for registration forms, contact Jay F. Watson, Treasurer, USFWS Suite 1962, 500 N.E. Multnomah Street, Portland, OR 92232. Deadline for conference preregistration is October 1.

Computer-Aided Seismic Analysis

Deadline for abstracts of papers to be considered for the Second International Symposium on Computer-Aided Seismic Analysis and Discrimination is May 15. The symposium, slated for August 20 and 21, will be held at the Southeastern Massachusetts University in North Dartmouth, Massachusetts.

Papers in all aspects of computer-aided seismic analysis and discrimination are invited and solicited; solicited topics include mathematical techniques, digital filtering, computer network, data analysis, and pattern classification for seismic study. Special sessions on non-Gaussian signal processing and high-resolution spectral analysis are also planned.

The symposium is cosponsored by the IEEE Computer Society; the IEEE Acoustics, Speech, and Signal Processing Society; the Pattern Recognition Society; the IEEE Geoscience and Remote Sensing Society; and the electrical engineering department at Southeastern Massachusetts University.

For additional information and for registration forms, contact C. H. Chen, Electrical Engineering Department, Southeastern Massachusetts University, North Dartmouth, MA 02747 (telephone: 617/999-8475).

MEETING ANNOUNCEMENT
LUNAR AND PLANETARY INSTITUTE TOPICAL CONFERENCE
Co-Sponsored by NASA and NSF
PROCESSES OF PLANETARY RIFTING

December 3-5, 1981
Christian Brothers' Retreat House
Napa Valley, California

CONVENERS: B.H. Baker and P. Morgan
SESSIONS PLANNED:
1) Speculations as to the origin and development of rifts
2) Constraints on rift evolution - setting
3) Constraints on rift evolution - geological development
4) Constraints on rift evolution - physics and chemistry of the lithosphere
5) Resources associated with rifting
6) Our state of ignorance and its remedy

Attendance will be limited to 60 participants. Send a letter of application with a brief, but specific outline of potential contributions to the meeting, including a provisional title if you plan to submit an abstract, to Rift Meeting, Projects Office, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, Texas 77058, USA. Deadline for applications is May 29, 1981. Further information can be obtained from the above address, or phone (713) 486-2150.

GAP

Separates

To Order: The order number can be found at the end of each abstract; use all digits when ordering.

Cost: $3.50 for the first article and $1.00 for each additional article in the same order. Payment must accompany order.

Deposit Account: A minimum of $10.00 may be placed on deposit with AGU for the purchase of separates. If funds are on deposit, the cost of the first article is only $2.00 and $1.00 for each additional article in the same order.

Separates will be mailed within 3 weeks of journal publication or within 10 days if ordered after the journal has appeared. Separates are available for purchase for two years from date of publication.

Copies of English translations of articles from Russian translation journals are available either in unedited form at the time of their listing in EOS or in final printed form when a journal is published. The charge is $2.00 per Russian page.

Send your order to:
American Geophysical Union
2000 Florida Avenue, N.W.
Washington, D.C. 20009

Meteorology

3715 Chemical composition and chemical interactions
SIMULTANEOUS SPECTROSCOPIC DETERMINATION OF THE LATITUDINAL, SEASONAL AND DIURNAL VARIABILITY OF STRATOSPHERIC N_2O, NO, NO_2 AND HNO_3
[illegible]

several of the more uncertain parameters of the model. [illegible] ... the source for N_2O ... the tropospheric ... to loss of CH_3CCl_3 ... the troposphere ... suggest that ... should be ... more definitive ... of release ... measurements ... sphere. (Tropospheric chemistry, global budgets).
J. Geophys. Res., Green, Paper 1C0623

3720 Climatology
SPATIAL AND TEMPORAL VARIATIONS OF MONTHLY MEAN TOTAL COLUMN OZONE DERIVED FROM 7 YEARS OF BUV DATA
R. H. Tolson (NASA Langley Research Center, Hampton, Virginia)

The monthly mean total columnar ozone fields are represented by ninth degree spherical harmonic models. [illegible] ... with estimation theory techniques to develop a realistic error analysis that accounts for errors due to nonglobal coverage. Over the 7 year data set, systematic variations are represented by an annual, semi-annual, and biennial model, along with secular trends where required. The annual component of zonal mean ozone compares favorably with previous results based on Dobson data. The semiannual term is shown to be the dominant variation near the South Pole. In the Tropics, the results support the theory that enhanced Hadley cell circulation is responsible for the biennial variation in zonal mean ozone. Amplitude and phase variations for longitudinal waves 1, 2, and 3 are presented. In the Northern Hemisphere, these waves reinforce in space and time during the period of high poleward transport of ozone. In the Southern Hemisphere, the wave 2 and 3 components are much smaller, and wave 1 maximum amplitude occurs in September and October.
J. Geophys. Res., Green, Paper 1C0578

3720 Climatology
STRATOSPHERIC AEROSOLS AND THE TROPOSPHERIC ENERGY BUDGET: THEORY VS OBSERVATIONS
James A. Coakley, Jr. (National Center for Atmospheric Research)

Changes in the diffuse and direct solar radiative fluxes observed at the surface can serve as a direct indication of how efficiently a stratospheric aerosol layer removes solar energy from the troposphere and thereby causes tropospheric cooling. Observed changes after the eruption of Agung in 1963 are compared with estimates derived from published results of theoretical calculations for the impact of stratospheric aerosols on the earth's energy budget. The comparison reveals that the aerosol layer that formed after Agung could have caused two to three times the tropospheric cooling obtained with the theoretical calculations. The discrepancy is however mitigated by the large uncertainties associated with the observations. Because of the large uncertainties, the theoretical results cannot be regarded as unrealistic. To reduce the observational uncertainties, it is recommended that 1) the change in diffuse to change in direct flux ratio be derived from observations of the diffuse to direct ratio obtained with a single instrument so that errors associated with photometric calibration are eliminated, 2) ancillary observations be made so that changes caused by a stratospheric aerosol layer may be isolated from other changes in the atmosphere, and 3) observations be made at sites where background changes are minimal.
J. Geophys. Res., Green, Paper 1C0654

3725 Chemical composition and chemical interactions
[illegible]

3735 Electrical Phenomena
TWO-DIMENSIONAL INTERFEROMETRIC POSITIONS OF VHF LIGHTNING SOURCES
Craig O. Hayenga (Research and Development Division, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801) & James W. Warwick
Using a new radio interferometric technique, we present observations of VHF [illegible]

lightning radiation source positions. [illegible] ... J. Geophys. Res., Green, Paper 1C0577

3740 General Circulation
ASPECTS OF STRATOSPHERIC SUDDEN WARMINGS STUDIED FROM A TRANSFORMED EULERIAN-MEAN VIEWPOINT.
T.N. Palmer (Meteorological Office, Bracknell, Berkshire, England.)

The stratospheric major warmings of 1979 and 1980 are discussed from a transformed Eulerian-mean viewpoint. [illegible] ... J. Geophys. Res., Green, Paper 1C0618

3745 Gravity waves, tides, and compressional waves
FURTHER STUDY OF A JET STREAM-GENERATED KELVIN-HELMHOLTZ INSTABILITY
J. Klostermeyer (Max-Planck-Institut für Aeronomie, 3411 Katlenburg-Lindau 3, Fed. Rep. Germany) R. Rüster
High-resolution VHF Doppler radar measurements during a jet stream passage [illegible] ...

During the growth stage, the vertical profile [illegible] ... J. Geophys. Res., Green, Paper 1C0555

3750 Instruments and techniques
[illegible]

3755 Instruments and techniques
WIND MEASUREMENT TECHNIQUES AVAILABLE FOR THE MIDDLE ATMOSPHERE PROGRAM
F. Cage (Aeronomy Lab, NOAA/ERL, 325 Broadway, Boulder, CO 80303) and T. VanZandt
The study of atmospheric dynamics in the Middle Atmosphere Program (MAP) will depend strongly on both the quality and quantity of wind measurements taken during the program. This paper presents a survey of the status of the many techniques which can be utilized to measure wind in the middle atmosphere. [illegible] ... J. Geophys. Res., Green, Paper 1C0557

Mineralogy, Petrology, and Crystal Chemistry

4260 Petrogenesis, petrography, and petrogenesis
THE MINERALOGY AND CHEMISTRY OF THE ANOROGENIC TERTIARY SILICIC VOLCANICS OF S.E. QUEENSLAND AND N.E. NEW SOUTH WALES, AUSTRALIA
A. Ewart (Dept. of Geology & Mineralogy, University of Queensland, St. Lucia, Brisbane, Queensland 4067)

The Late Oligocene-Early Miocene volcanism of this region is chemically strongly bimodal; the mafic lavas (volumetrically dominant) comprise basalts, hawaiites, and tholeiitic andesites, while the silicic eruptives are mainly comendites, potassic trachytes, and potassic, high-silica rhyolites. The comendites and rhyolites have distinctive trace element abundance patterns, notably the extreme depletions of Sr, Ba, Mg, Mn, P, Cr, V, and Eu, and the variable enrichment of such elements as Rb, Zr, Pb, Nb, Zn, U, and Th. The trachytes exhibit these characteristics to lesser degrees. The comendites are distinguished from the rhyolites by their overall relative enrichment of the more highly charged cations (e.g. LREE, Nb, Y, and especially Zr) and Zn.

The phenocryst mineralogy of the trachytes and rhyolites comprises various combinations of the following phases: sodic plagioclase (albite-andesine), calcic anorthoclase, sanidine, quartz, ferroaugite-ferrohedenbergite, ferrohypersthene, fayalitic olivine, ilmenite, titanomagnetite, and rarely biotite (near annite) and Fe-hastingsitic amphibole. Accessories include apatite, zircon, chevkinite (ferrohedenbergite-bearing rhyolites only), and allanite (amphibole and biotite rhyolites only). The comendites generally contain Ca-poor anorthoclase-sanidine, quartz, fluor-arfvedsonite, aegirine and aegirine-augite (Zr-bearing), aenigmatite, ± ilmenite.

Coexisting Fe-Ti oxides are absent in the comendites, and relatively uncommon in the rhyolites and trachytes; where present they indicate equilibration temperatures of 885-930°C, and f_{O_2} between QFM and MW buffers. The magmas are thus interpreted to have been strongly water undersaturated [illegible]

4260 Petrogenesis, petrography, and petrogenesis [illegible]

4270 Properties of minerals [illegible]

Oceanography

4760 Sea ice [illegible]

4765 Surface waves, tides and sea level
FIELD OBSERVATIONS OF SURF BEAT: PART 1 PROGRESSIVE EDGE WAVES
D.A. Huntley (Department of Oceanography, Dalhousie University, Halifax, Nova Scotia, Canada) R.T. Guza and E.B. Thornton

Nineteen biaxial electromagnetic current meters have been used to determine the longshore and on/offshore structure of currents at surf-beat periods (1 - 4 minutes). The sensors formed two linear arrays, a longshore array within the surf-zone and an on-offshore array stretching from the shoreline to well beyond the breaker line. Analysis of the longshore current components yields a clear picture of progressive low-mode edge waves, with frequency-wavenumber dispersion relations which are in remarkably good agreement with predictions. Some separation of edge wave modes is found, with mode zero energy dominating in the frequency band 0.006 and 0.011 Hz and mode one between 0.015 and 0.025 Hz. On/offshore currents present a rather different picture which, while not inconsistent with the longshore currents, suggest that other sources of energy are also important to the on/offshore currents. These include standing edge waves probably formed by reflections at nearby Scripps Canyon, and motions which are non-resonantly forced by incoming wave groups.
J. Geophys. Res., Green, Paper 1C0556

Particles and Fields—Interplanetary Space

5310 Cosmic rays
SOLAR CYCLE MODULATION OF GALACTIC COSMIC RAYS: SPECULATION ON THE ROLE OF CORONAL TRANSIENTS
Gordon Newkirk, Jr., A.J. Hundhausen and V. Pizzo (High Altitude Observatory, National Center for Atmospheric Research, P.O. Box 3000, Boulder, Colorado 80307) [illegible]

5310 Cosmic rays
COSMIC RAYS AND THUNDERSTORM FREQUENCY [illegible]

5380 Solar wind plasma
CORONAL STREAMERS IN THE SOLAR WIND AT 1 AU [illegible]

Particles and Fields—Ionosphere

5515 Auroras [illegible]

5515 Auroras
AURORAL X-RAY IMAGES
B. H. Mauk (Geophysics AK-50, University of Washington, Seattle, Washington 98195) J. Chin and G. Parks.

A new X-ray "pin-hole" camera has been developed to study the spatial and temporal characteristics of the energetic component of auroral electron precipitation. The camera obtains spectral information on bremsstrahlung X-rays with energies between 22 and 110 keV, and it details spatial structure with scale lengths between 10 and 80 km (9 to 62 degree cone angles). The camera has been deployed by a balloon into several auroral break-up associated events. In this first report preliminary images are shown from these events, and several types of observed phenomena are discussed. These phenomena include the observation of a spectrally soft, 20 km spot which appeared to initiate a major break-up event and which appeared together with a component which was spectrally hard and spatially uniform. The timing of this event, the multiple components, and the discrepant spatial scales are reminiscent of geostationary observations of dispersionless substorm injections. Also discussed is the slow evolution of X-ray burst generating regions, as well as the spatial modulation of precipitation by hydromagnetic oscillations (Pc-3) within the magnetosphere. It appears that small scale spatial structure (~15 km) is a prominent feature of energetic electron precipitation
J. Geophys. Res., Blue, Paper 1A0635

5515 Auroras
TANGENTIAL ELECTRIC FIELDS IN A DRIFTING AURORAL ARC
A.W. Yau (Herzberg Institute of Astrophysics, National Research Council of Canada, Ottawa, Canada K1A 0R6), J.A. Whalen and F. Creutzberg

We report rocket-borne ion convection velocity and ground-based optical measurements in an early evening, equatorward drifting, NW-SE oriented auroral arc. Our measurements indicate a detail[illegible]

5515 Auroras
OPTICAL EMISSIONS AND IONIZATION PROFILES DURING AN INTENSE PULSATING AURORA [illegible]

5520 Electric fields
GLOBAL IONOSPHERIC ELECTRIC FIELD MEASUREMENTS IN APRIL 1978 [illegible]

5520 Electric fields
GLOBAL IONOSPHERIC ELECTRIC FIELD MEASUREMENTS IN APRIL 1978 [illegible]

5520 Electric fields [illegible]

[illegible] eastward velocities above. A plausible explanation for this shear is that the westward drifts are driven by electric fields produced by westward E region winds and mapped up along magnetic field lines, while at higher heights, where the electron density is greater, the drifts are controlled by the F region dynamo driven by eastward winds.
Geophys. Res. Lett., Paper 1L0319

5530 High-latitude ionospheric currents
RELATIONSHIP BETWEEN THE AE AND DST INDICES DURING GEOMAGNETIC STORMS
S.-I. Akasofu (Geophysical Institute, University of Alaska, Fairbanks, Alaska 99701)

During moderately disturbed periods, the AE and Dst indices have a simple linear relationship. However, it is shown that their relationship is considerably different during geomagnetic storms. As the |Dst| index grows above 50γ, the AE index levels off and tends to decrease. This finding may have interesting implications in understanding the formation of the ring current belt.
J. Geophys. Res., Blue, Paper 1A0421

5535 Interactions between waves and particles
ELECTRON-ION COLLISION EFFECTS ON THE FORMATION OF PROMPT STRIATIONS IN THE IONOSPHERE
J. L. Sperling (JAYCOR, P. O. Box 85154, San Diego, California, 92138) and N. A. Krall

Electron-ion collisions have been included in the analysis of electrostatic, purely growing, finite ion-gyroradius, flute instabilities generated by a loss cone distribution of energetic ions in the ionosphere. It is shown that the collisions not only reduce the growth rate below the value predicted by collisionless theory, but also result in a second lower growth rate mode not found in collisionless theory. Although the electron-ion collision frequency is larger than the ion-gyrofrequency for the parameters of the Buaro barium release experiment, the growth rate of the linearly most unstable mode is not appreciably modified by the collisions from the value predicted from collisionless theory. Electron-ion collisions have a greater impact on the instability as the electron density is increased. Complete stabilization through electron-ion collisions requires densities in excess of [illegible]
J. Geophys. Res., Blue, Paper 1A0514

5535 Interactions between waves and particles
AN INTENSE WAVE/PARTICLE EVENT IN THE AURORAL IONOSPHERE [illegible]

5540 Ion densities and temperatures
PLASMA DENSITY FEATURES ASSOCIATED WITH STRONG CONVECTION IN THE WINTER HIGH-LATITUDE F-REGION [illegible]

5545 Ionospheric disturbances [illegible]

5570 Total Electron Content
IONOSPHERIC TOTAL ELECTRON CONTENT BEHAVIOR AT A PAIR OF MID-LATITUDE CONJUGATE STATIONS [illegible]

5590 Electric fields [illegible]

Particles and Fields—Magnetosphere

5715 Electric fields [illegible]

5715 Electric fields [illegible]

5720 Interactions between solar wind and magnetosphere [illegible]

5720 Interactions between solar wind and magnetosphere [illegible]

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